DØ: Physics Results and Analysis Plan

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Fermilab

DOE Annual Science and Technology Review

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U.S. DEPARTMENT OF ENERGY

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Outline

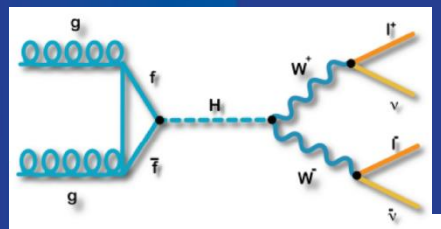
- Summary of physics results since June 2009
  - Higgs searches
  - Evidence for anomalous CP violation in B mixing
  - Other results in top, electroweak, QCD
  - Searches for new physics
- Analysis plans
  - Collaboration status
  - Fermilab role
  - Higgs physics
  - Tevatron flagship measurements

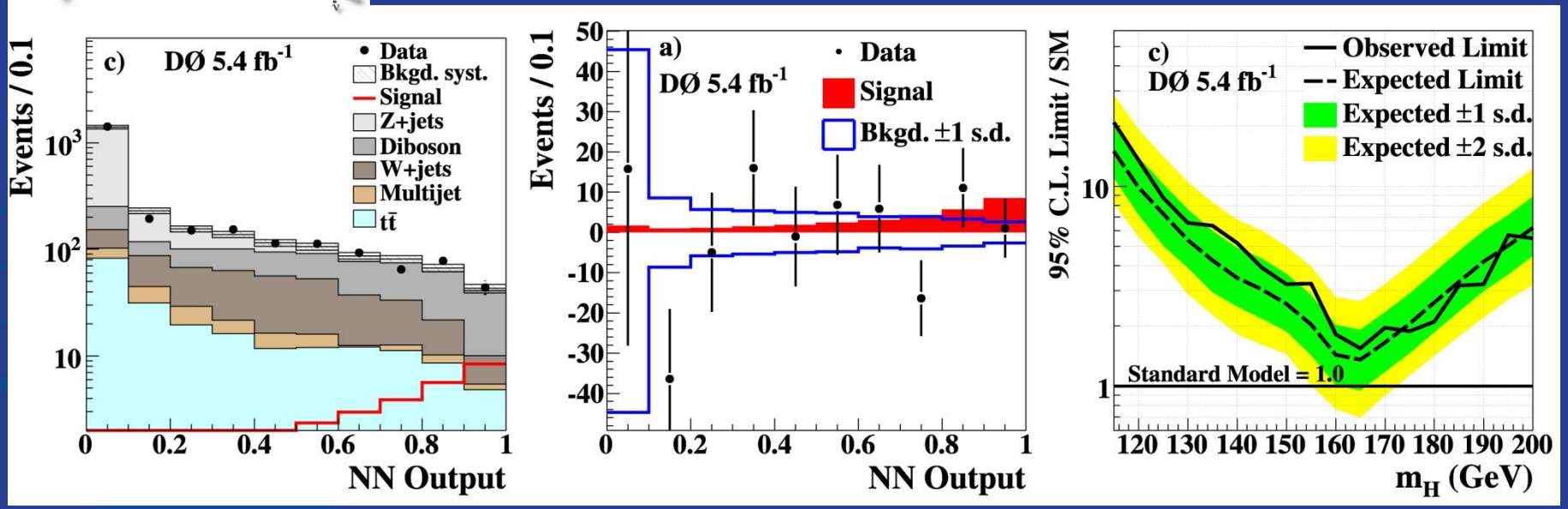
DØ Physics Results since June 2009

- Higgs searches
  - SM Higgs
  - BSM Higgs
  - Short term prospects (ICHEP/HCP)
- New Physics in b-quarks ?
  - Search for $B_s \rightarrow \mu\mu$
  - Evidence for anomalous CP violation in like-sign dimuon pairs
- Standard Model Physics
  - Top
  - Electroweak
  - QCD
- Searches for Physics Beyond the SM

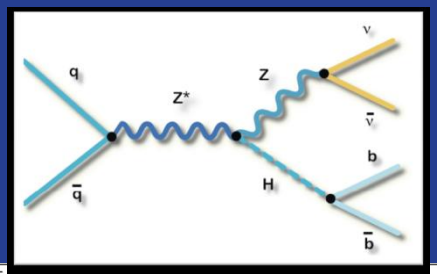
SM Higgs Searches at DØ (I)

- Published search for H→WW→lνlν (5.4 fb^{-1})
  - Expected sensivity at 165 GeV: 1.36*SM
  - Observed limit @ 95% C.L.: 1.55*SM
  - Combination with CDF: exclude SM Higgs between 162 and 166 GeV
    - PRL 104, 061804(2010) (D0), PRL 104, 061802 (2010) (combination), arXiv.org:1005.3126 (PRD-RC, 4th generation models)

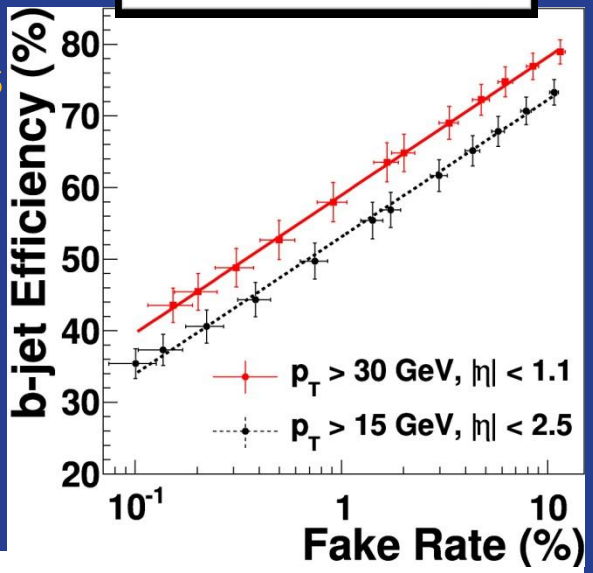


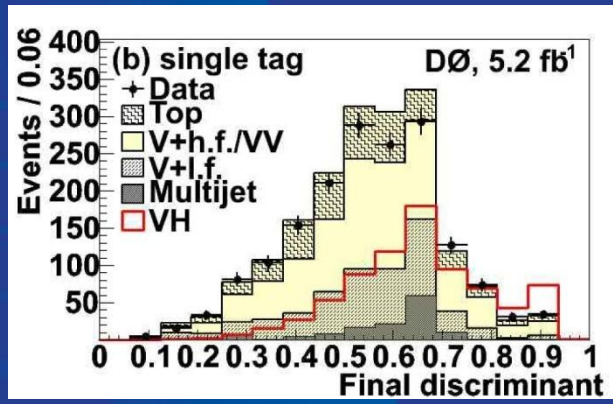


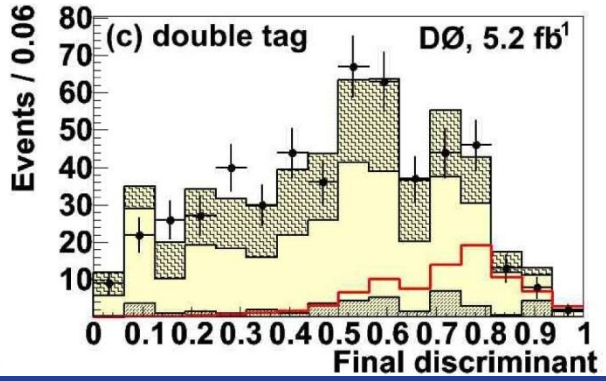
Higgs Searches at DØ (II)

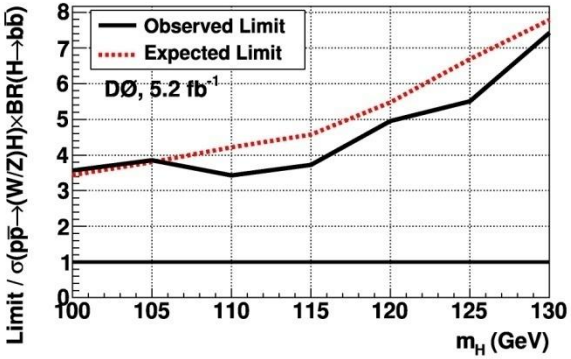


- Published search for ZH→vvbb (5.2 fb^{-1})
  - Acoplanar dijets final states, with 1or 2 b-tags
  - Data driven background estimation
  - Improvements in b-tagging
    - NIM A 620, 400 (2010)
  - Expected sensivity at 115 GeV: 4.6*SM
  - Observed limit @ 95% C.L.: 3.7*SM
    - PRL104, 071801 (2010)

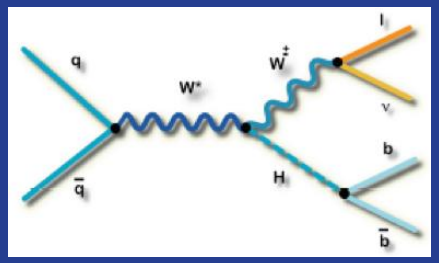




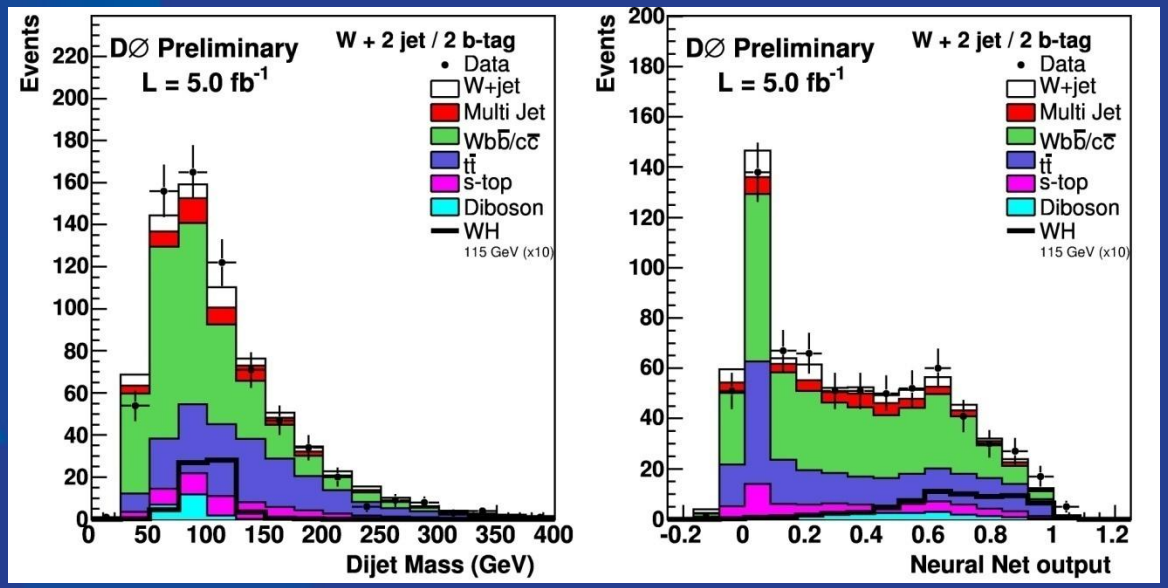




SM Higgs Searches at DØ (III)



- Preliminary results for WH→lνbb (5 fb^{-1})
  - Lepton(e/μ/τ) + jets +missing ET final states, with 1 or 2 b-tags
  - Expected sensivity at 115 GeV: 5.1*SM
  - Observed limit @ 95% C.L.: 6.9*SM
  - Updated analysis to be presented at ICHEP, submitted for publication soon



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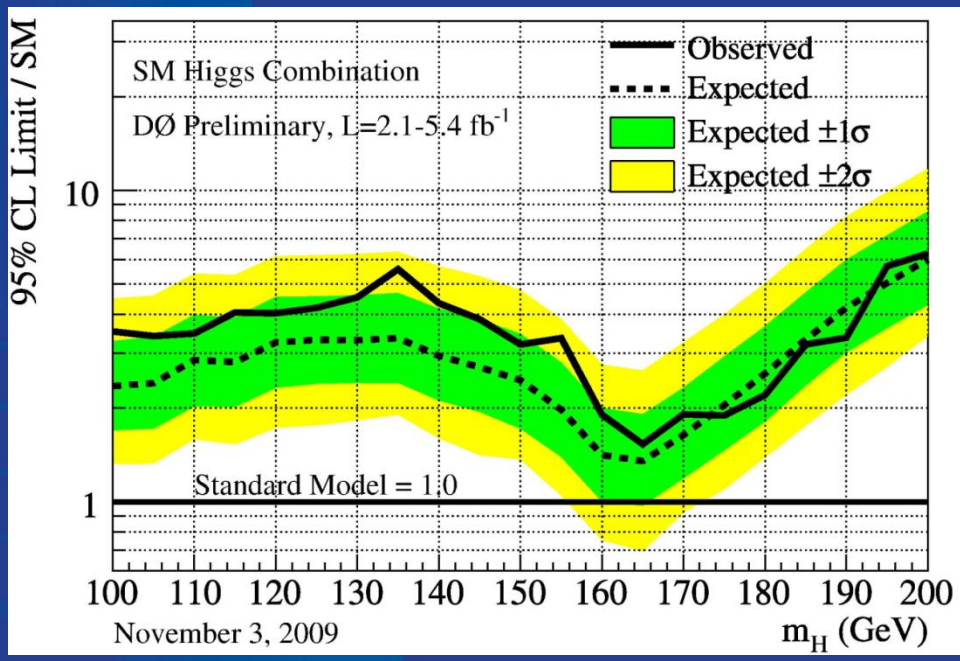
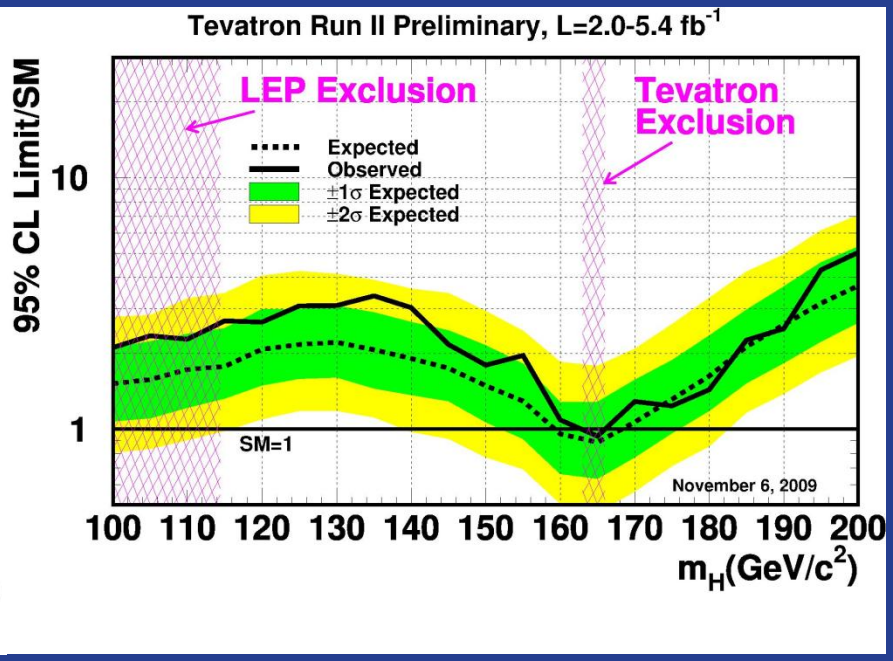
SM Higgs Searches at DØ (IV)

- Current DØ combination of SM Higgs Searches
  - Presented at Winter conferences 2010
  - To be updated next week (almost all analyses with > 5 fb^{-1})





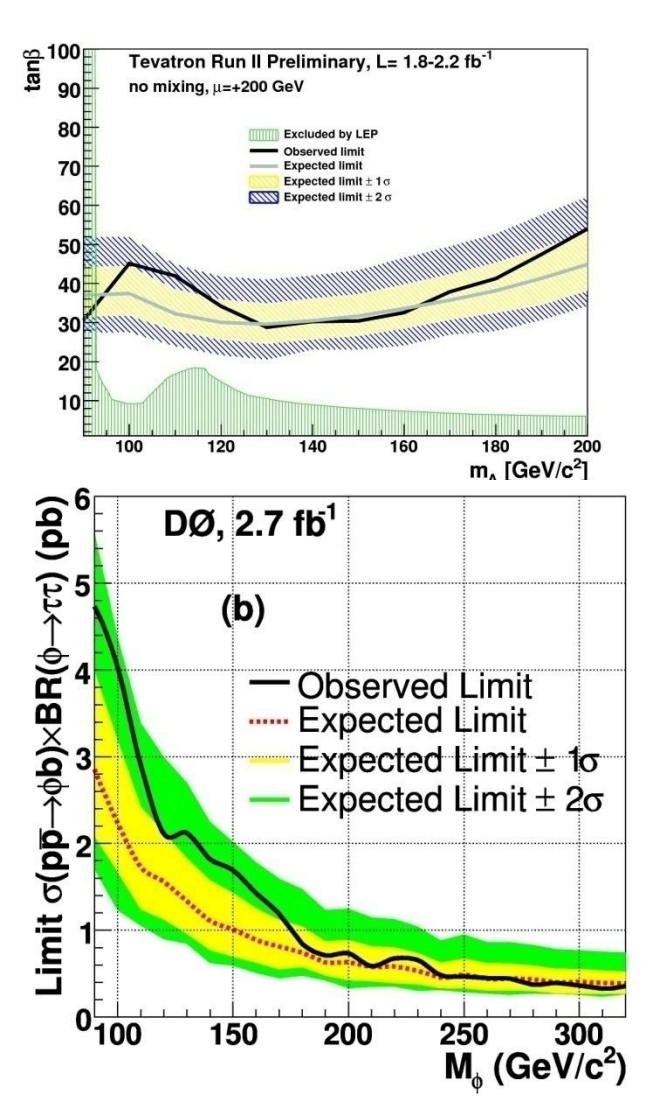
SM Higgs Searches at DØ (V)

- Preliminary result for $ZH \rightarrow llbb$ (4.2 fb^{-1})
  - Dileptons (e/μ/isolated track) + jets
  - Journal submission this week
- Preliminary result for $\tau\tau qq$ final state (4.9 fb^{-1})

- Updates with 5.4-6.7 fb^{-1} by ICHEP (high mass)
  - Improved analysis, include lvjj final state, approach SM sensitivity
- Updates with 6.7 fb^{-1} by end August for all analyses
  - Improvements in b-tagging
  - Better signal/background discrimination
  - Publish all results with > 5 fb^{-1} before the Fall
  - Add $\mu\tau$ channel for $H \rightarrow WW$

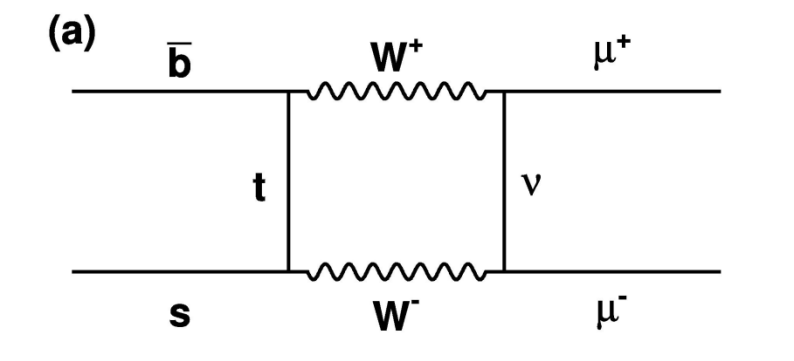
SUSY Higgs Searches at DØ

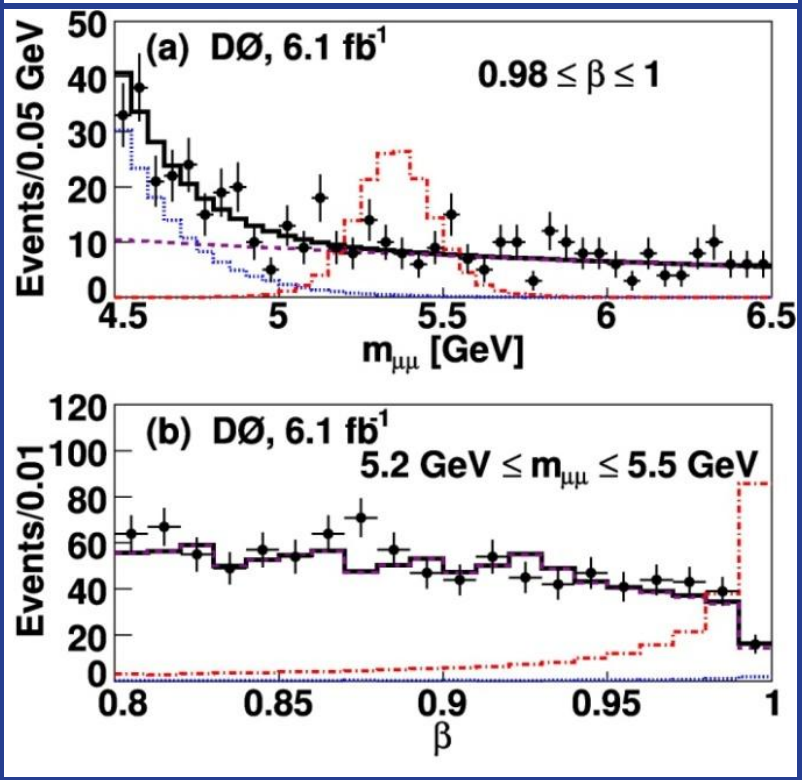
- $H \rightarrow \tau\tau$ (~5 fb^{-1})
  - Publication with $e\mu$ and $\mu\tau_{had}$ before the Fall
  - NB: First combination of CDF and DØ results in this channel (Winter 2010)
- $bH \rightarrow b\tau\tau \rightarrow b\mu\tau_{had}$ (2.7 fb^{-1})
  - ICHEP update with 5 fb^{-1}, working also on electron channel
    - PRL 104, 151081 (2010)
- $bH \rightarrow bbb$ (5.2 fb^{-1})
  - Submitted for publication prior to ICHEP, in Collaboration review
  - DØ combination of all 3 channels
  - Update with 6.4 fb^{-1} for the Fall



New Physics in b-quark Decays ? (I)

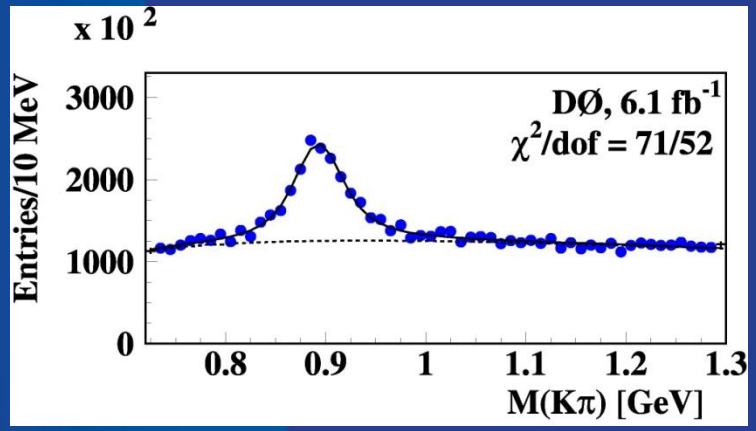
- Search for $B_s \rightarrow \mu\mu$ (6.1 fb^{-1})
  - Increased luminosity
  - Higher signal efficiency/acceptance
  - NN for background rejection
- Limit on the BR
  - $4.2*10^{-8}$ (expected)
  - $5.1*10^{-8}$ (observed)
  - Best published result to date, 11*SM
    - arXiv.org:1006.3469, submitted to PRL

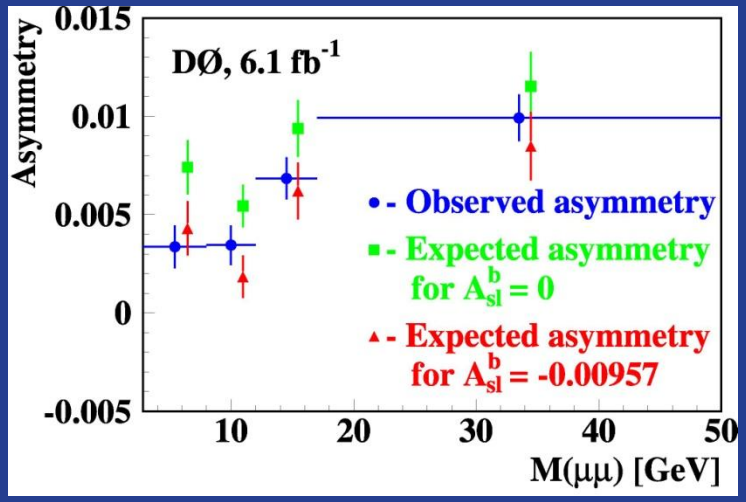




New Physics in b-quark Decays ? (II)

- Evidence for an anomalous like-sign dimuon charge asymmetry
  - Measure charge asymmetry of single-muon and like-sign muon pairs
  - Single muon: dominated by background (K decays/punch-through)
  - Use asymmetry in single muon sample to constrain background for measurement in like-sign dimuon pairs
  - 2nd muon in like-sign dimuon pairs acts as flavor tag
  - All backgrounds and relative asymmetries measured in data

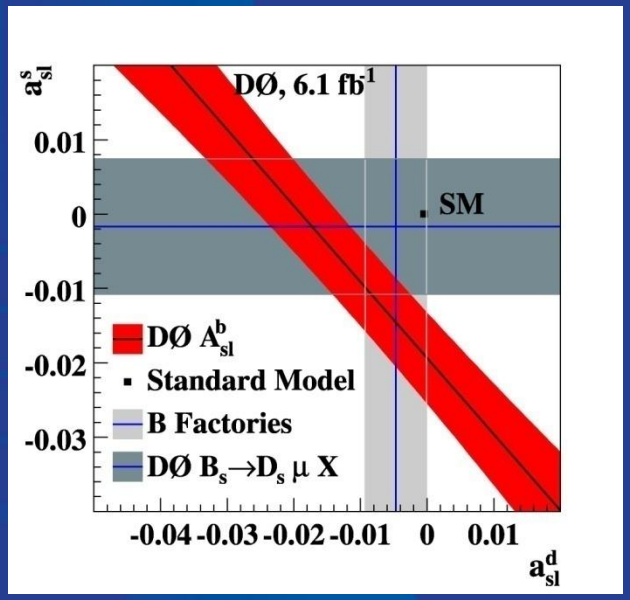


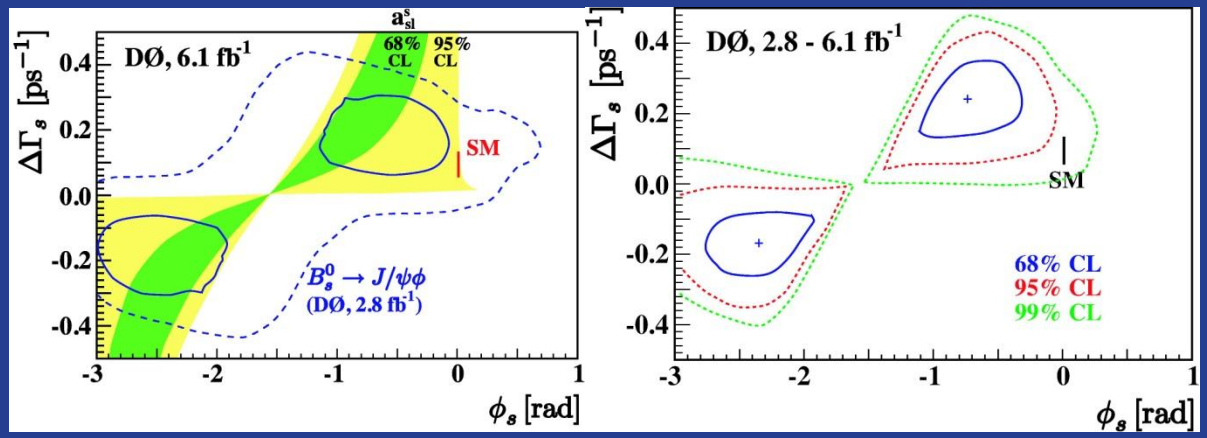


New Physics in b-quark Decays ? (III)

- Evidence for an anomalous like-sign dimuon charge asymmetry
  - Measure: A^b_{sl}=-0.00957±0.00251(stat) ±0.00146 (syst)

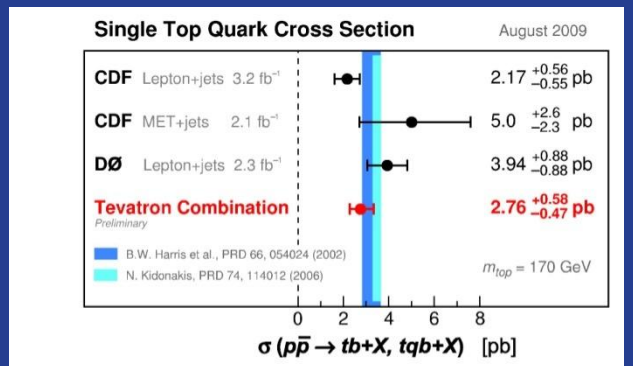
    $A^b_{sl}(SM)=(-2.3^{+0.5}_{-0.6})*10^{-4}$
    - arXiv.org:1005.2757 (submitted to PRD) and 1007.0395 (submitted to PRL)
  - Expect new result on $B_s \rightarrow J/\psi+\varphi$ for ICHEP (+combination with CDF)

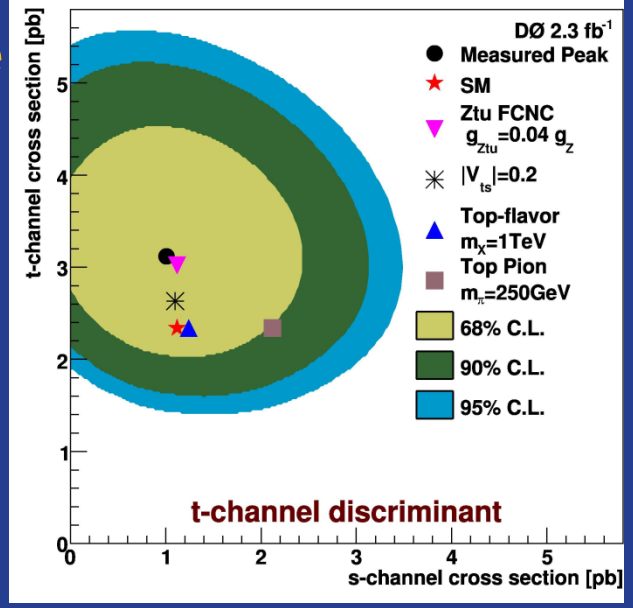




New top Physics Results (I)

- Many results based on observation of single top production (2.3 fb^{-1})
  - Combination of CDF+D0 measurements
  - Measured cross section with τ +jets final state
  - Measurement of t-channel cross section (4.8 s.d.)
  - Limits on FCNC (tcg/tug vertices)
- Extraction of top width (preliminary)
  - Uses t-channel cross section + branching ratio $t \rightarrow Wb$
  - $\Gamma_t = 2.05^{+0.57}_{-0.22}$ GeV

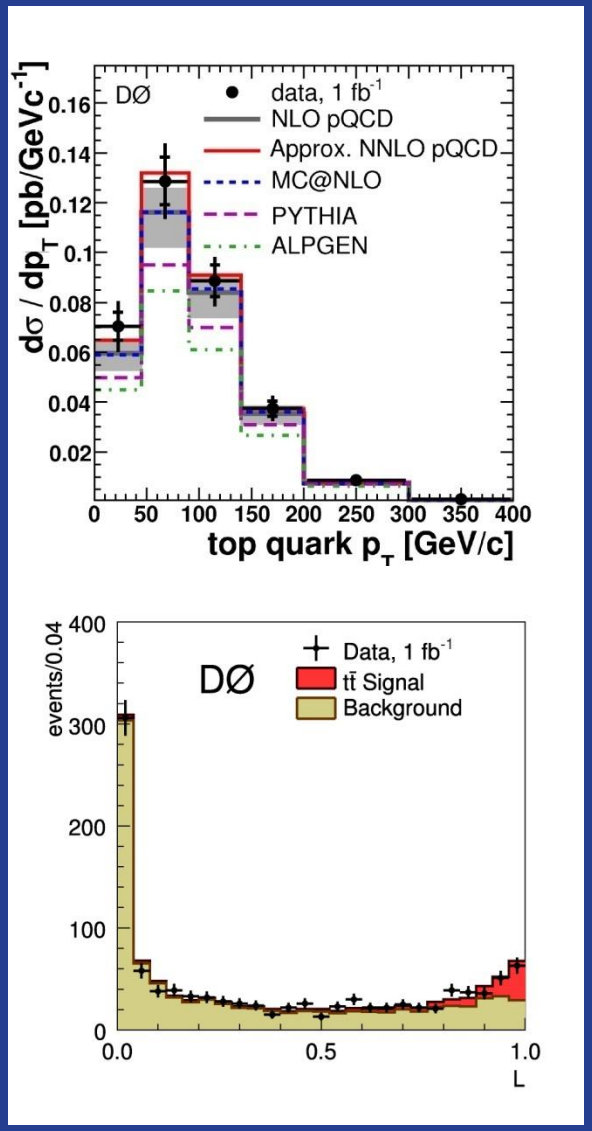




arXiv.org:0908.2171 [hep-ex]
PLB 690, 5 (2010)
PLB 682, 363 (2010)
arXiv.org:1006.3575 [hep-ex]

New top Physics Results (II)

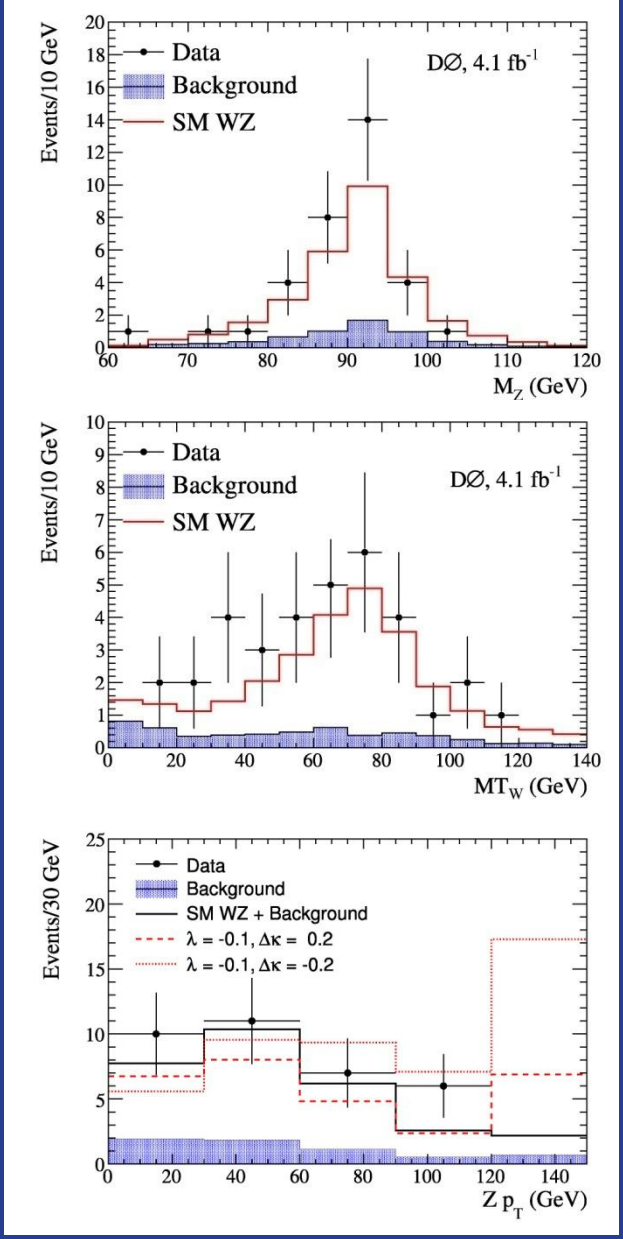
- Measurement of top differential cross section
  - $d\sigma/dp_T$ (arXiv.org:1001.1900 , submitted to PLB)
- Measurement of tt cross section
  - Fully hadronic final state (arXiv.org:0911.4285, PRD)
  - τ +jets final state (will submit this week)
- Other measurements (5 fb^{-1})
  - Improve all cross section measurements
  - W helicity
  - t' searches
  - tt resonances
  - Spin correlations
  - All results expected on Fall timescale



Electroweak Physics (I)

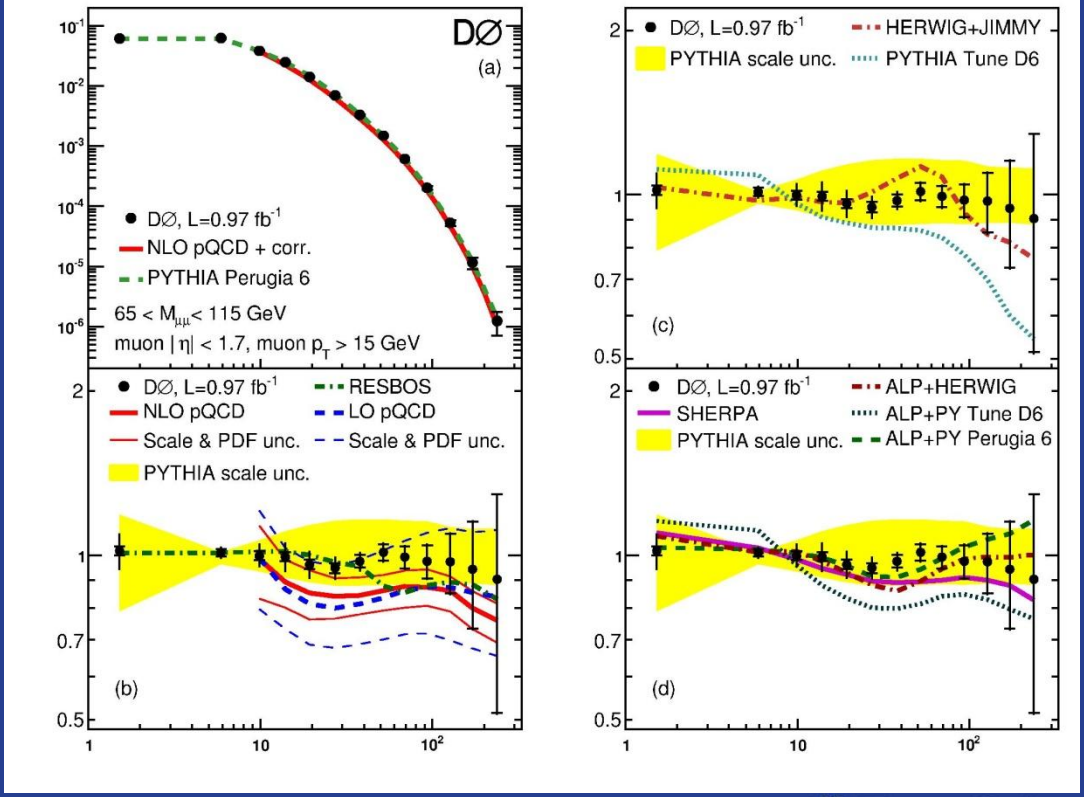
- Updated diboson cross section
  - WZ → trileptons
  - 34 candidate events, 6.0±0.4 background
  - $\sigma = 3.90^{+1.06}_{-0.90}$ pb
    - arXiv.org:1006.0761, submitted to PLB
  - Tightest constraints on WWZ vertex

- Constraints on triple gauge couplings
  - Combination of DØ measurements
  - WWγ/WWZ vertices, Wγ , WZ → trileptons, WW/WZ → lνjj
  - Approaching LEP limits
    - arXiv.org:0907.4952 [hep-ex]



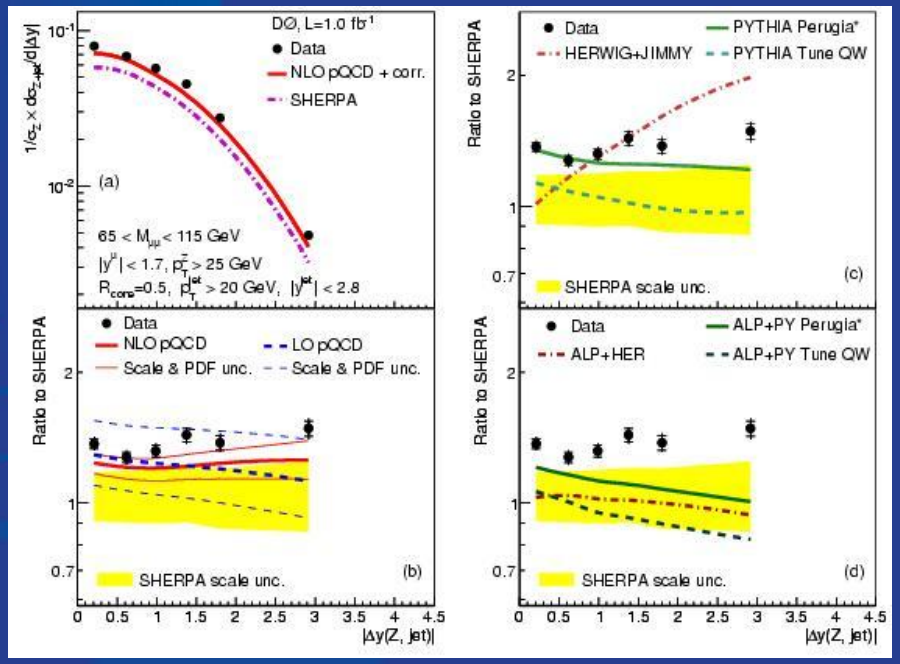
Electroweak Physics (II)

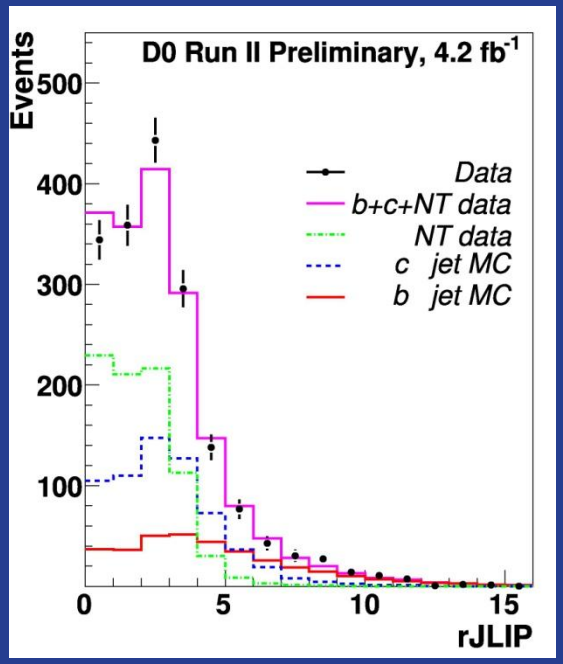
- Measurements of Z inclusive production
  - Constrain production model (W mass systematics)
  - Tests of QCD, MC models
    - arXiv.org:1006.0618 , submitted to PLB
  - New analysis with optimized variables to be published next week (7.3 fb^{-1})



Electroweak Physics (III)

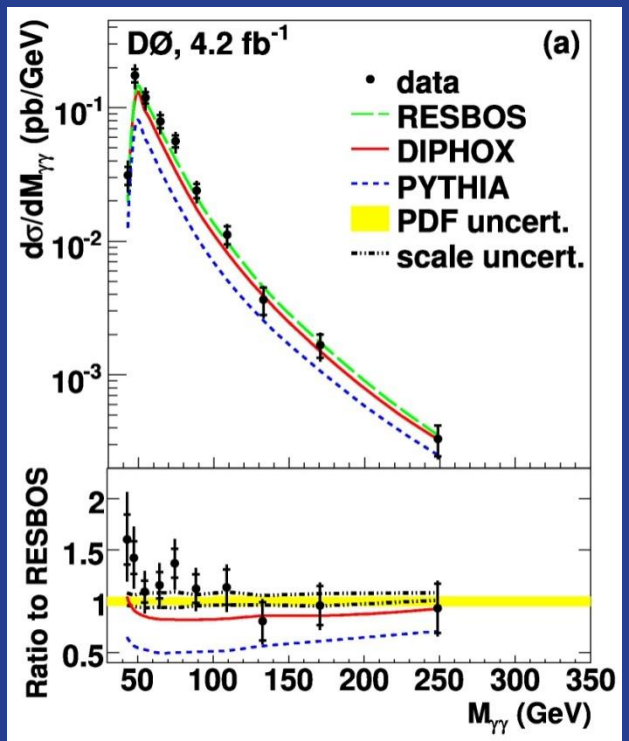
- Measurements of Z+jets (differential) cross sections
  - Various angular correlations in Z+1 jet
    - PLB 682, 370 (2010)
  - Ratio $\sigma(Z+b)/\sigma(Z+jets)$ (preliminary, 4.2 fb^{-1})
    - Measured ratio of cross sections important for Higgs searches
- Full program of measurements with W+jets in progress

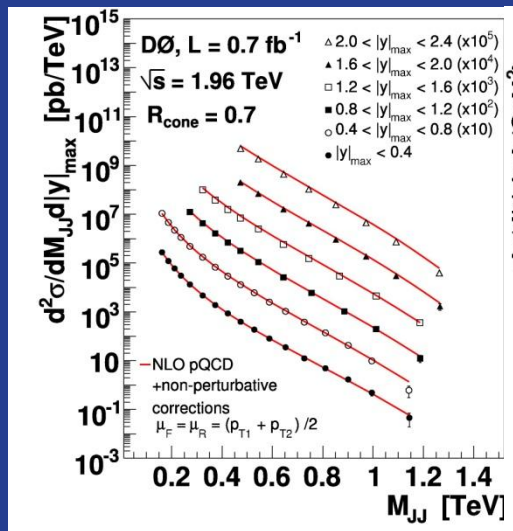


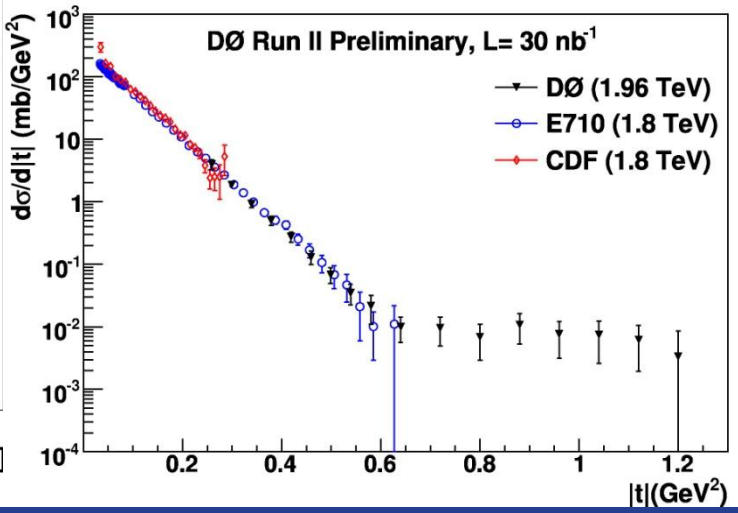


QCD (I)

- Cross sections
  - Diphotons (single/double differential)
    - PLB 690, 108 (2010)
  - Dijet mass
    - arXiv.org:1001.4594, submitted to PLB
  - 3-jet mass (preliminary)
  - Elastic cross section (preliminary)
  - Dijet production in exclusive diffraction (prel.)

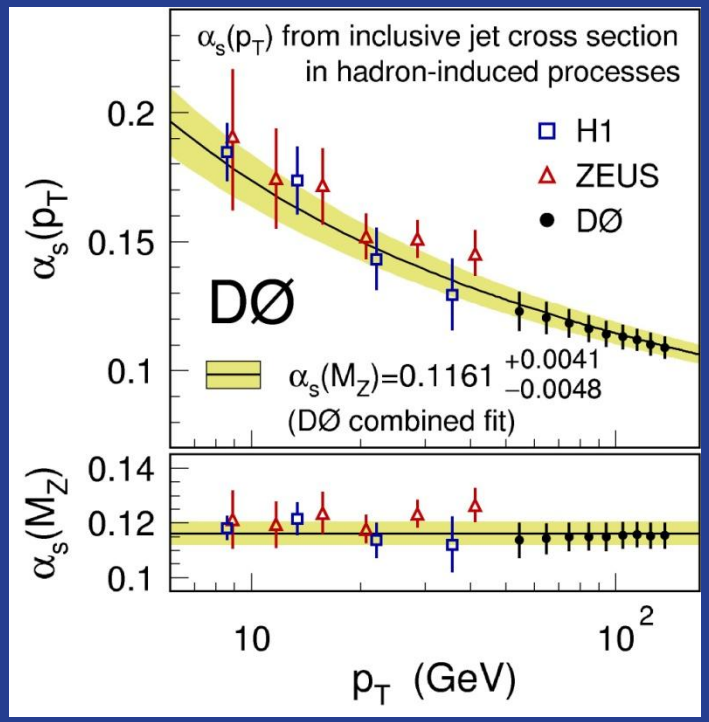


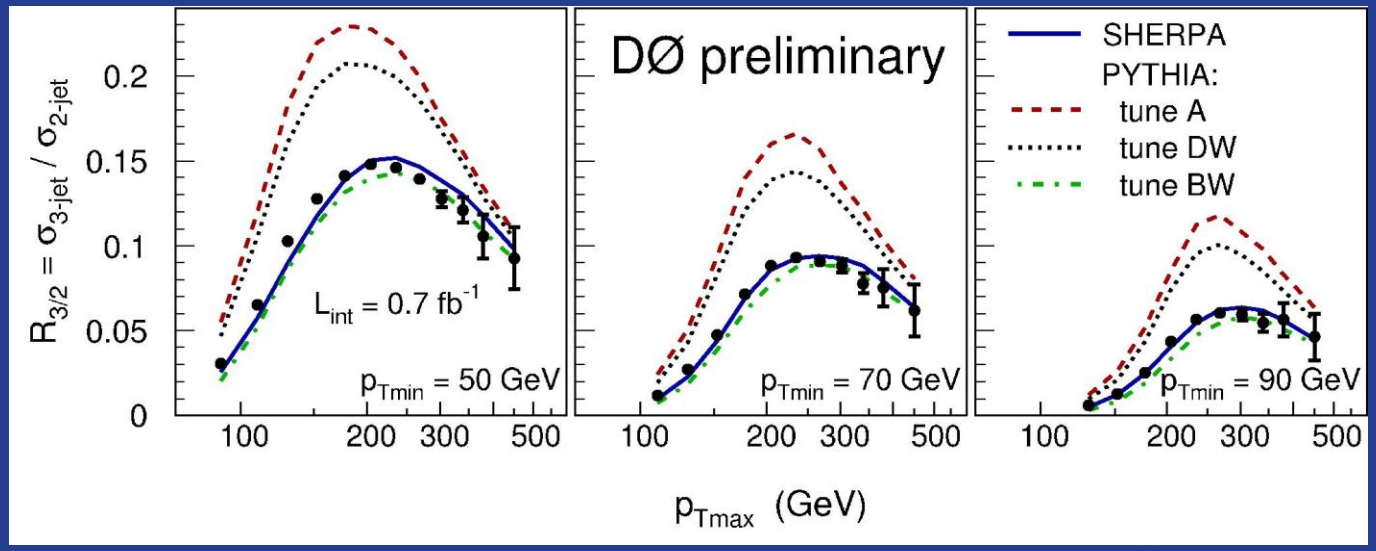




QCD (II)

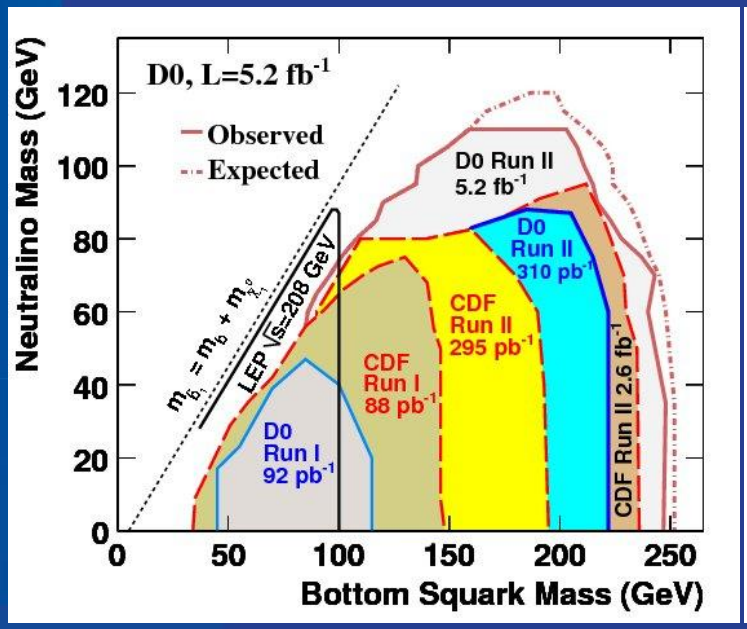
- Extraction of $\alpha_S(Q^2)$
  - From inclusive jet cross section
    - PRD 80, 111107R (2010)
  - From ratio R(3/2) (in progress)
    - Measure ratio vs p_T
    - Could test α_S running to 500 GeV

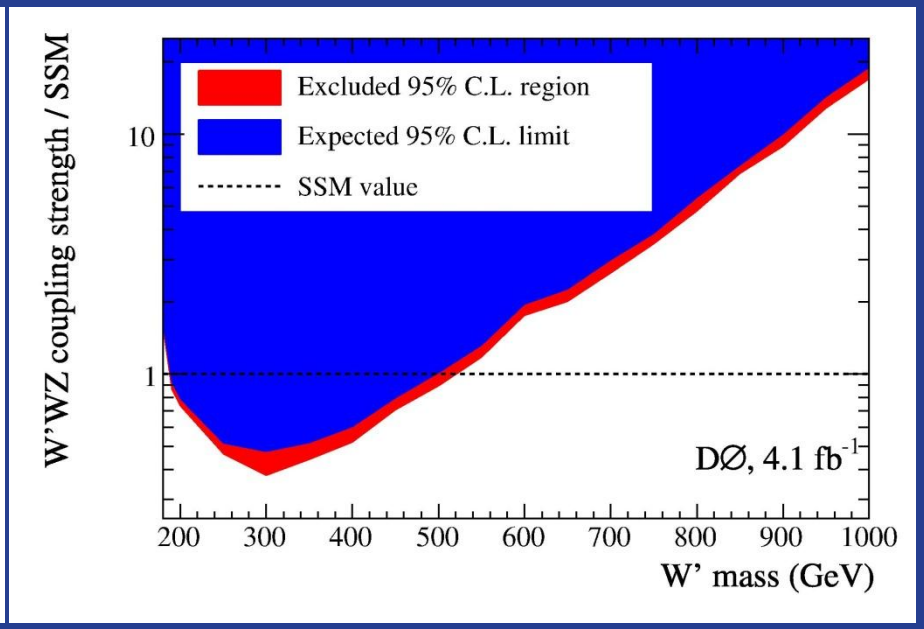




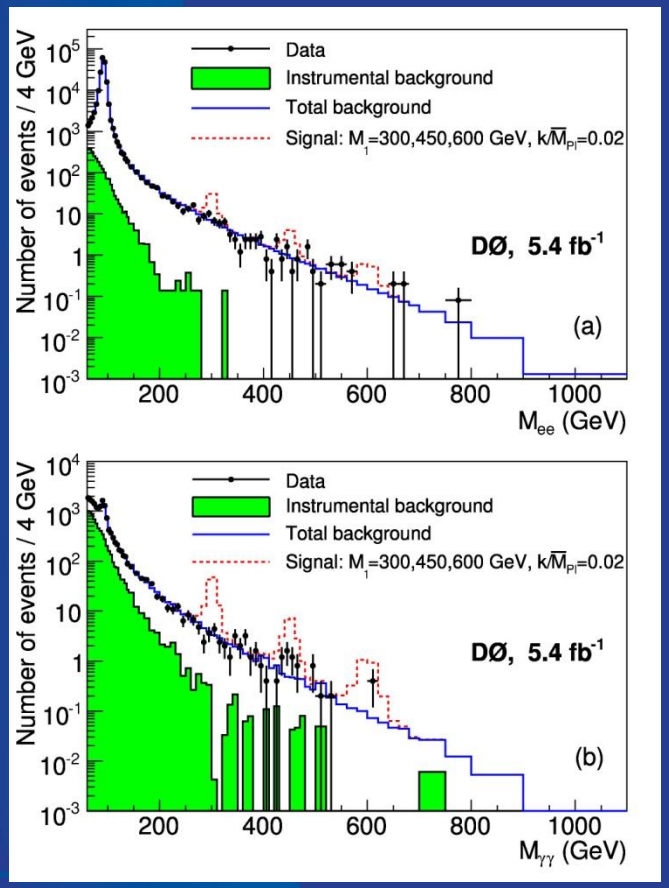
Beyond the SM (I)

- Different interpretation of other analyses
  - $\nu\nu$bb final state (3rd generation LQ, sbottom pair production)
    - arXiv:1005.2222 , submitted to PLB
  - WZ→trileptons (WZ resonance, W', technicolor)
    - PRL 104, 0618081 (2010)
    - Will soon extend to W+2 jets (test boosted jets techniques)
- Test new models (!!!)

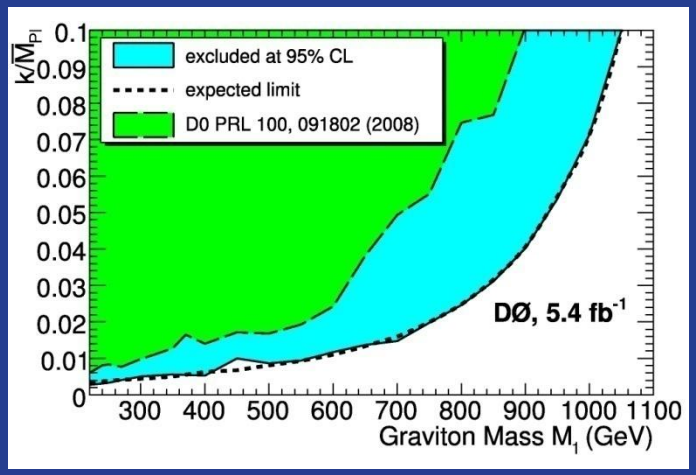




Beyond the SM (II)

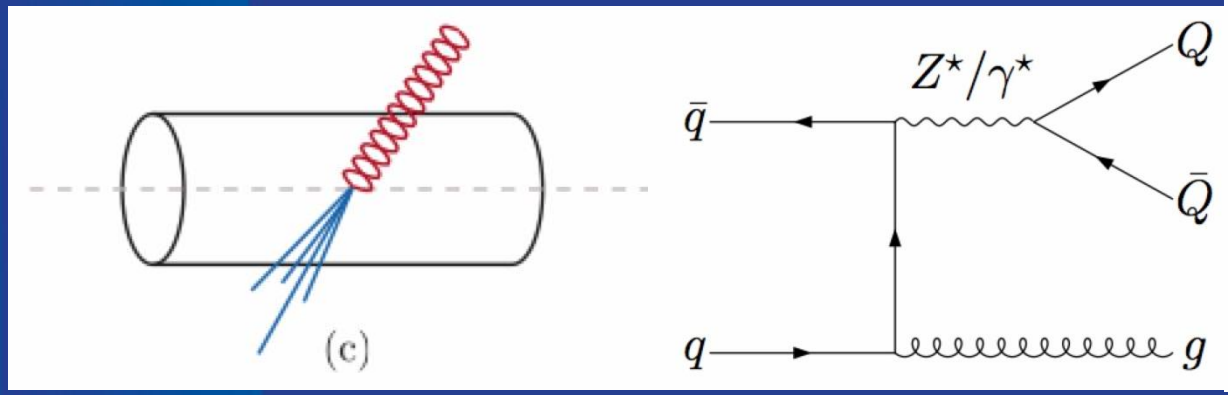


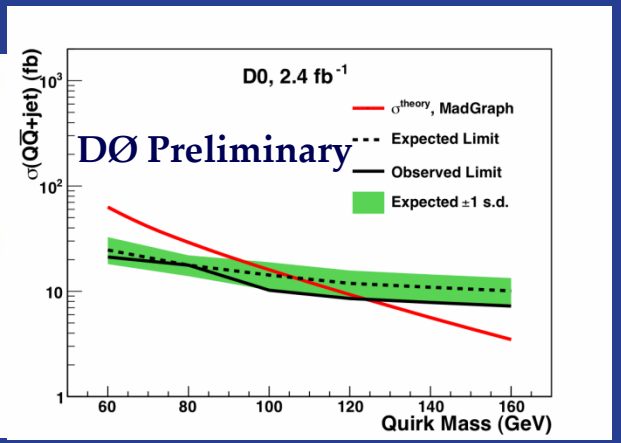
- Complementarity to LHC
  - Atlas/CMS will exceed Tevatron energy reach with O(100) pb^{-1}
  - Tevatron will still have an edge for weak couplings
  - Example: RS graviton search in ee/$\gamma\gamma$ final states
    - PRL 104, 241802 (2010)



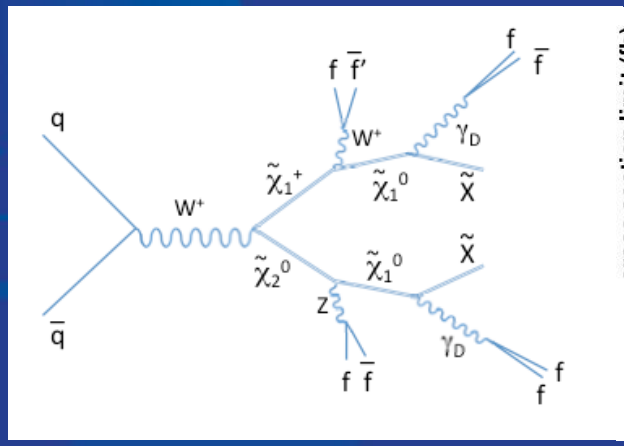
Beyond the SM (III)

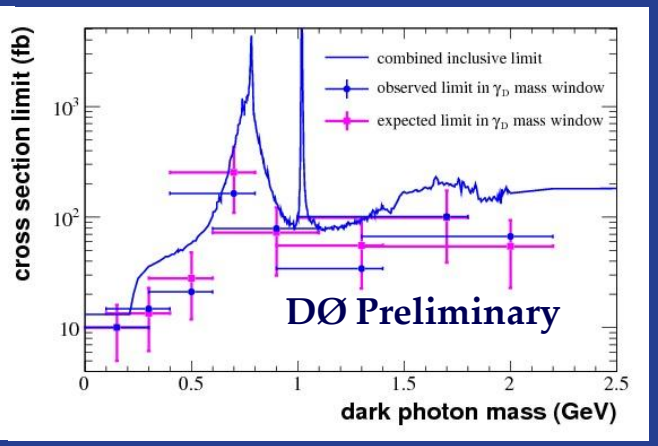
- Searches inspired by new models
  - Quirks (1 highly ionizing track per event, bound state of fermions with new quantum number)





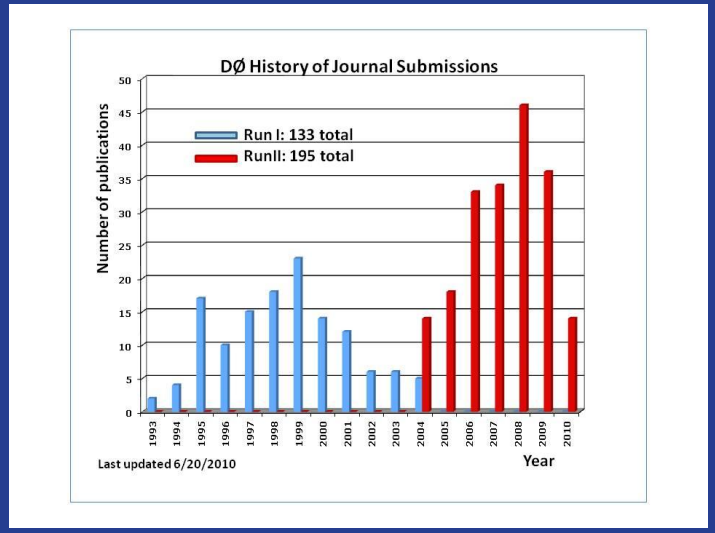
  - Leptonic jets (jets of e/m, from Hidden Valley models)





The DØ Collaboration (2010)

- 86 Institutions
  - 37 US, 49 non-US
- 19 Countries (+1)
- 492 Collaborators (-5%)
  - About 160 students / postdocs
- Journal submissions
  - 2009: 36 articles
  - 2010: 15 articles
    - Another 12 by ICHEP
    - Submit 200th Run II article this week
- Theses:
  - 2009: 34 Ph.D.
  - 2010: 15 Ph.D. (so far)



Fermilab Role in DØ (I)

- Role of Fermilab in analysis (past 12 months)
  - 1 of 2 spokespersons
  - 1 of 2 physics analysis coordinators
  - 1 QCD convener
  - 1 b-physics convener
  - 1 of 2 algorithm/computing coordinators
  - Participate in Higgs, top, QCD, b-physics and searches analyses
- Host Laboratory Support
  - 7 international fellows
  - ~ 40 local FTEs supported by visitor's budget
  - Crucial for successful detector operation
  - Critical impact on analysis effort

Fermilab Role in DØ (II)

- Personpower
  - Reduction of 9 Fermilab scientist FTEs since 2005
  - Many critical individuals not replaced
  - Create additional load on remaining Fermilab scientists, rest of the collaboration and guest/visitors budget
- Budget
  - Anticipated PPD FY11 guest/visitors budget 10% below FY10
  - Will affect ability of the experiment to collect/analyze data
  - Anticipated FY12 guest/visitors budget 70% below FY10, 40% of experiments' request
  - Will negatively affect operations, computing, physics analysis
  - Expect reductions in other areas including M&S, will impact scientific output of Tevatron program

Analysis Plans (2011 and Beyond) (I)

- Some guidance
  - UA2
    - Last SPS run in Fall 1990, published 10+2+2 articles in 91-93
  - DØ Run I
    - Continued to publish until 2004
  - Opal @ LEP (end of run in 2000)
    - Opal: flat publication rate @ 60% for 3 years (i.e. 20 articles / year for DØ), 3 more years to go down to few pubs / year
  - HERA (end of run in 2007)
    - Flat publication rate for 2.5 years (peak in 2009), slowdown in 2010 ?
- Expect to exceed 300 publications from Run II (200 this week)
  - Currently estimate more collaborators will be actively involved in 2010 and 2011 than expected in early 2009 (continue trend of recent year)
  - New graduate students / postdocs starting

Analysis Plans (2011 and Beyond) (II)

- General considerations
  - Datasets / reprocessing
    - Major upgrade in 2006 (1 fb^{-1} before, 7fb^{-1} and growing, after)
      - Trigger upgrade, Layer 0
    - Will consider reprocessing full RunII(b) data
      - Summer 2010 workshop end of July
    - Still improving MC description of data
- Analyses with full dataset (>10 fb^{-1})
  - Higgs searches, full spectrum (SM and BSM)
  - Associated production at low mass (WH, ZH, $\tau\tau$ final states)
  - $\gamma\gamma$ final state to help in intermediate mass region
  - Extend high mass analyses to low mass
  - SUSY Higgs: $\tau\tau$, bbb, b$\tau\tau$
  - Expect (almost) final results for Higgs searches by Summer 2012

Analysis Plans (2011 and Beyond) (III)

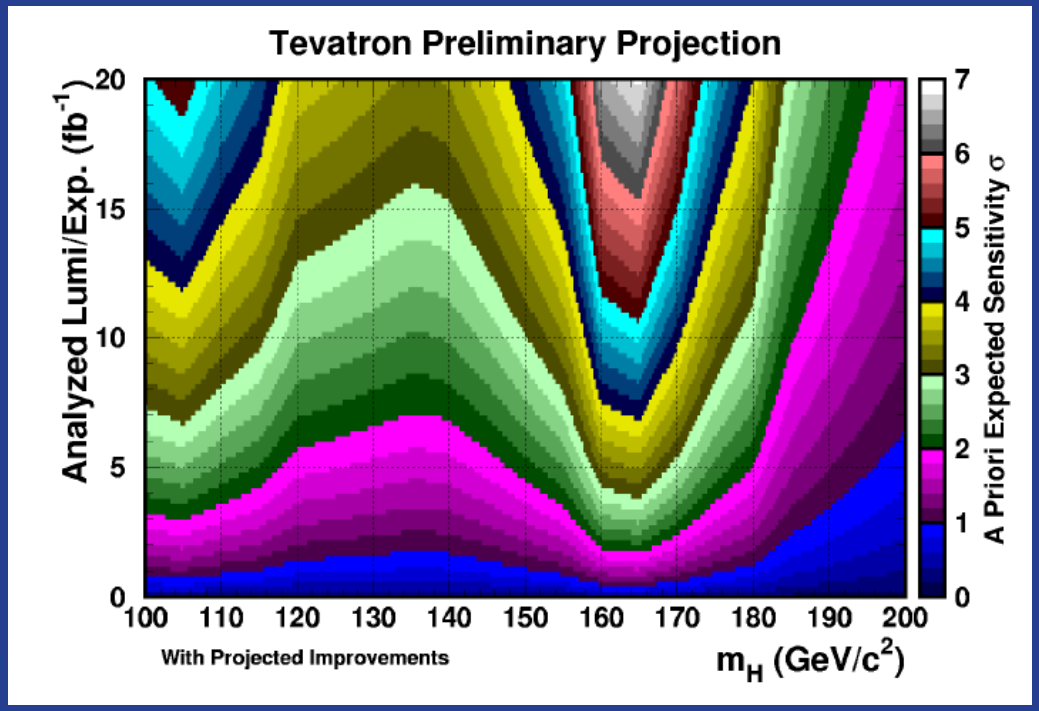
- Tevatron legacy measurements (>10 fb^{-1})
  - Top mass (systematics limited, below 1 GeV, 2012-2013)
  - Single top (separate s- and t-channel contributions)
  - W mass measurement (systematics driven by statistics)
    - Will publish 5 fb^{-1} measurement in the Fall
    - Expect uncertainty comparable to world average (25 MeV)
    - With full dataset (2012-2013) expect O(15 MeV) measurement
    - With ΔM_{top}=1 GeV and ΔM_W=15 MeV expect M_H<117 GeV @ 95 CL
  - Continue investigation of possible CP violation in B_s system
    - Expect LHCb to be competitive with Tevatron with 1 fb^{-1}
    - Will continue investigation of dimuon asymmetry
      - Further analysis improvements, B_s tags
      - Complementary with LHCb

Analysis Plans (2011 and Beyond) (IV)

- QCD
  - W/Z+jets
    - Will perform complete set of measurements (total + differential) cross section with current dataset (5-7 fb^{-1})
    - CDF+DØ combinations
    - Tevatron/theory working group (interest from LHC experiments)
  - Jets cross section
    - Already (0.7 fb^{-1}) systematics limited except for
    - Large masses, high rapidities, large jet multiplicities
    - Will repeat measurements with 7 fb^{-1} dataset
    - Tight timescale (end 2011)
    - Running of α_s over range (50-500 GeV)
  - Diboson cross sections
    - Perform measurements in all channels by Winter 2011
    - Combined limits on TGCs

Analysis Plans (2011 and Beyond) (V)

- Support for extension of Tevatron Running
  - 85% of institutions have signed Expression of Interest for continued Tevatron running
  - 3 years, total delivered luminosity 19 fb^{-1}, double analysis dataset
  - Increase chances of Higgs boson discovery



Conclusions

- DØ continues data taking and data analysis
- Tevatron: leading physics program at energy frontier
  - Expect many new results for ICHEP
  - Updated result with data up to April 2010 for low mass Higgs searches before the Fall
  - 30 articles submitted to journals since last review, 32 Ph.D. theses
  - Expect >10 submission prior to ICHEP (77 abstracts)
- Need to confirm current surprises
  - Evidence for asymmetry in like-sign dimuon pairs
- Presented preliminary outline of possible analyses after currently planned Tevatron shutdown in 2011
  - Expect large number of publications after end of data taking