DØ Analysis, Data Preservation and Decommissioning

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Outline

- Analysis at D0
  - Overview
  - Highlight recent results
  - Plans
- Data Preservation
- Decommissioning
- Conclusion

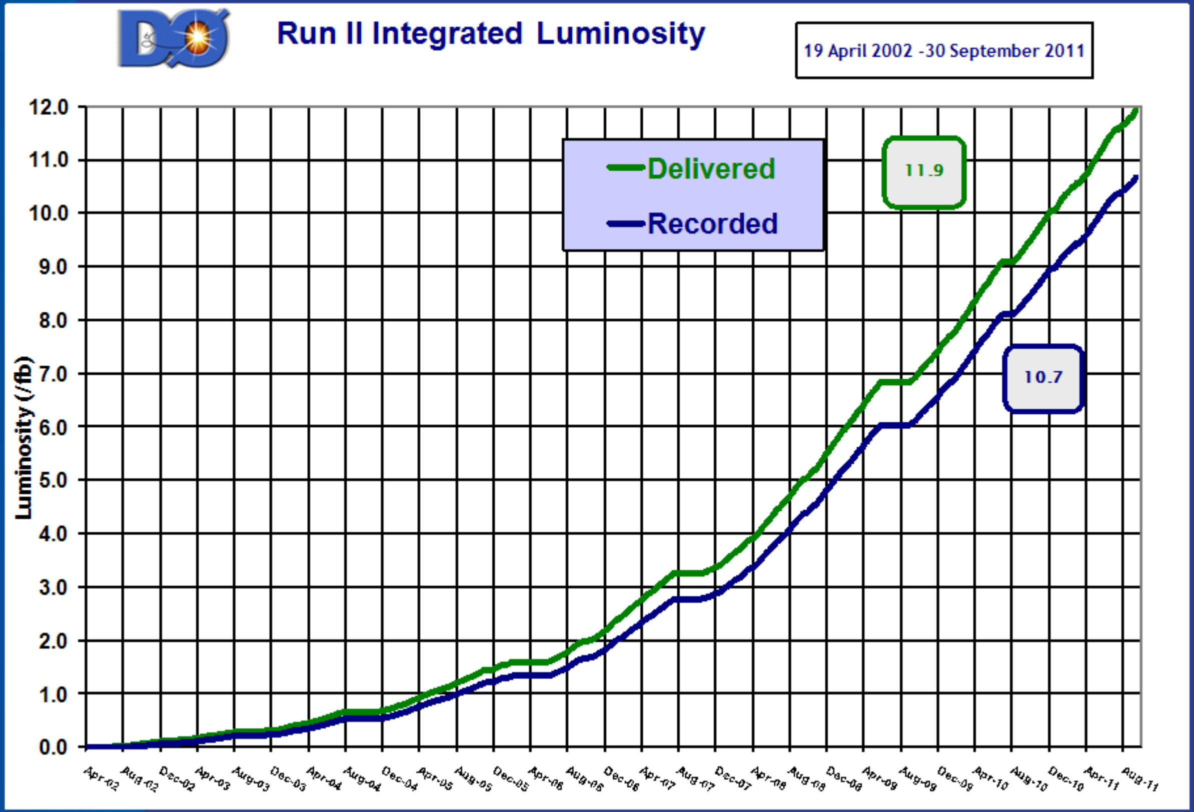
The DØ Collaboration

DØ is a collaboration of 384 physicists from 18 nations

- **Institutions**
  - **75 total**
- **Collaborators**
  - **~50% from US**
- **Fermilab scientists represent ~6% of the collaboration**

September 2011 Collaboration Photo

Dataset size vs time



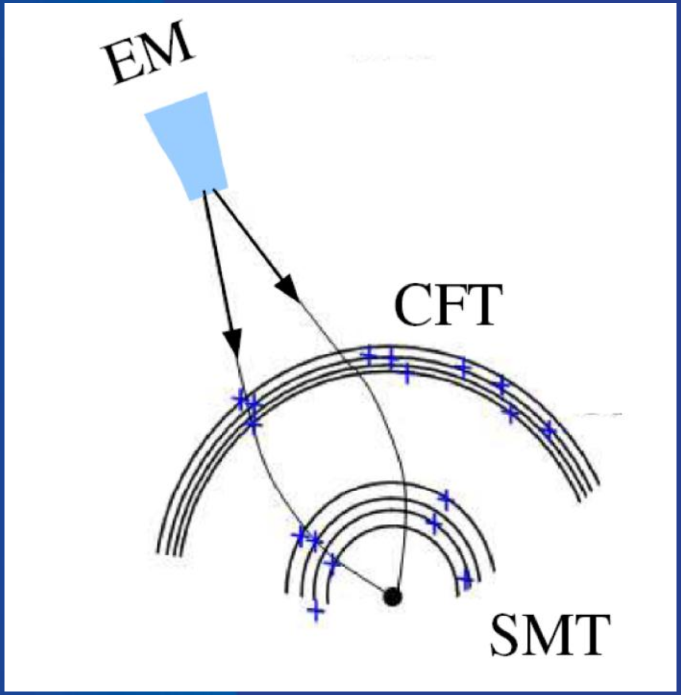
Many thanks to FNAL's Accelerator Division

- **Full dataset 10.7 fb^{-1} ≈ 10 billion events reconstructed Oct 2011**
- **Selected subset ≈ 1 billion events reprocessed March 2012**

Reprocessing improvements list

- Tracking in road for central electrons
- Endcap e/γ: find tracking hits where track wasn't
- Uniform primary vertex ID algorithm
- Best alignments for each data period
- Fake track killer v2.0 (CFT time & light yield)
- Correct for faster CAL gain drop for RunIIb4
- Updated SMT Lorentz shifts
- SMT event by event pedestal and luminosity dependent shifts
- Time-since-L1-accept & other DAQ data available

Reprocessing improvement example

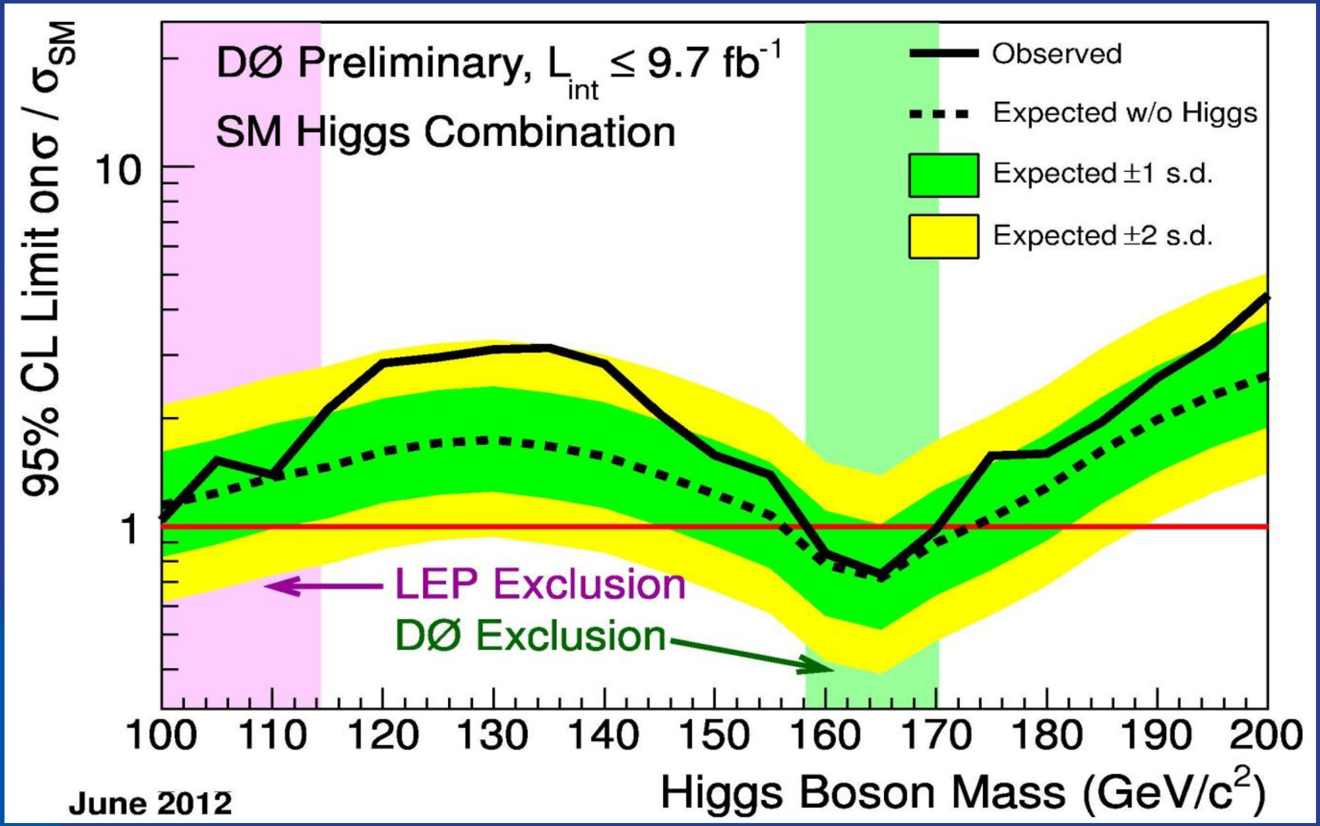


"Track in road" means start with identified EM cluster in calorimeter, nominal interaction point, and repeat the tracking algorithm
92% → 99% efficiency in Monte Carlo

"Hits in road" means look for tracking system hits not assigned to tracks near these two hypothetical paths – improves purity of γ samples

ANALYSIS HIGHLIGHTS

DØ S.M. Higgs Results from full dataset



- **Combination of ~20 analyses for each Higgs decay modes**
- **Exclusion at high masses**
- **Obtained limit ~2σ worse than expected for $m(H)$ ≈ 120-140 GeV**

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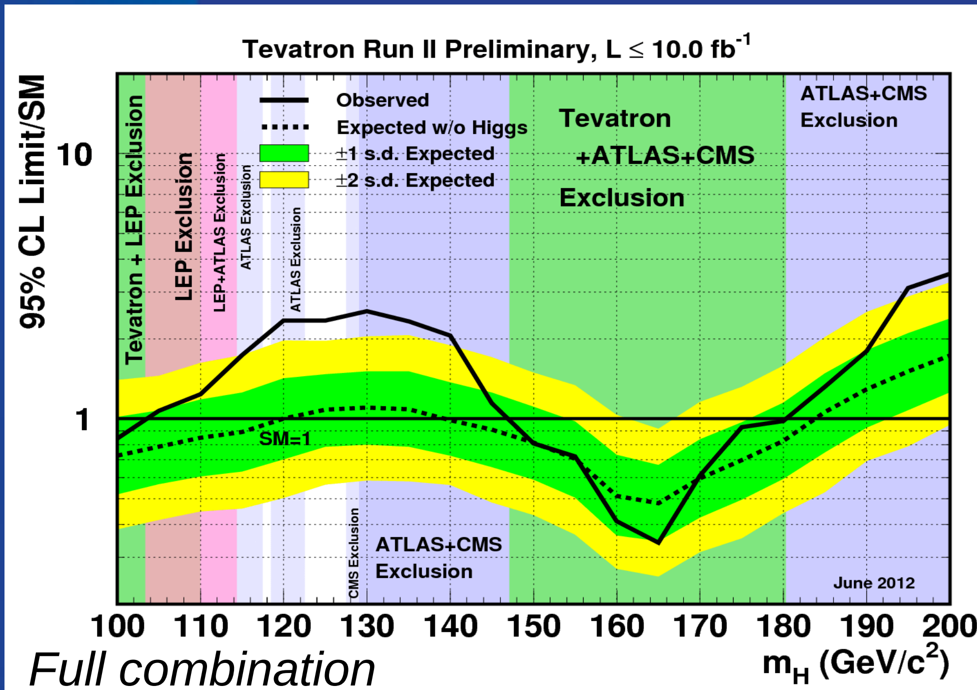
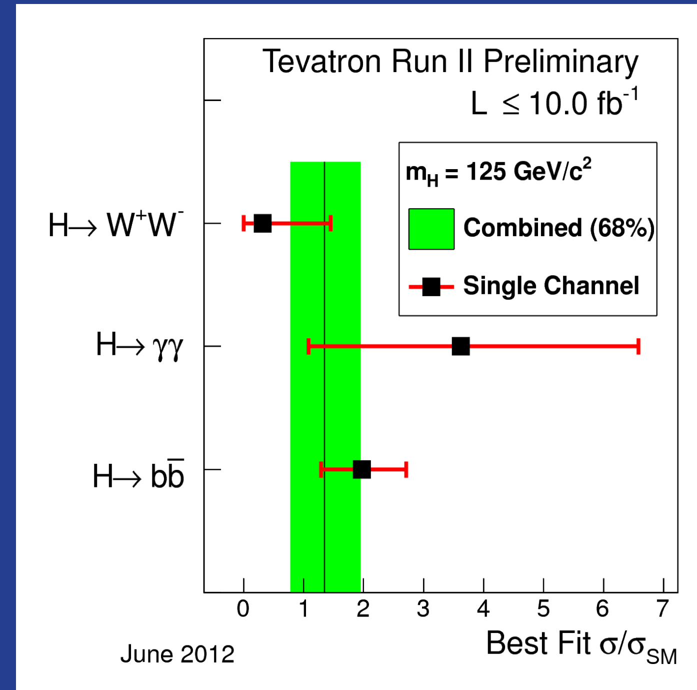
CDF + DØ S.M. Higgs Results from full dataset

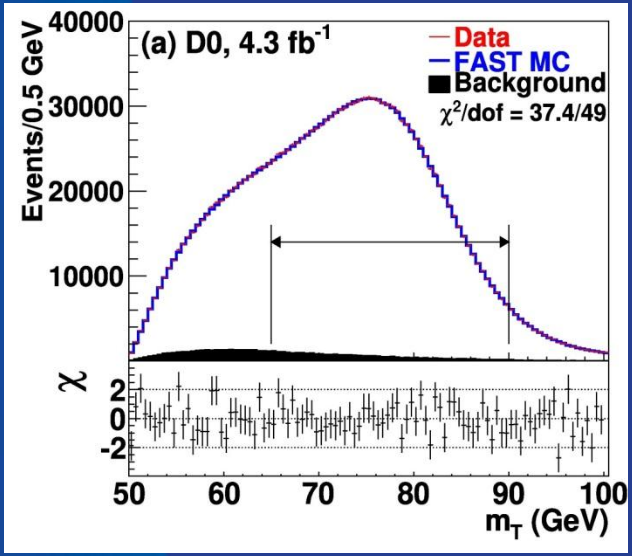


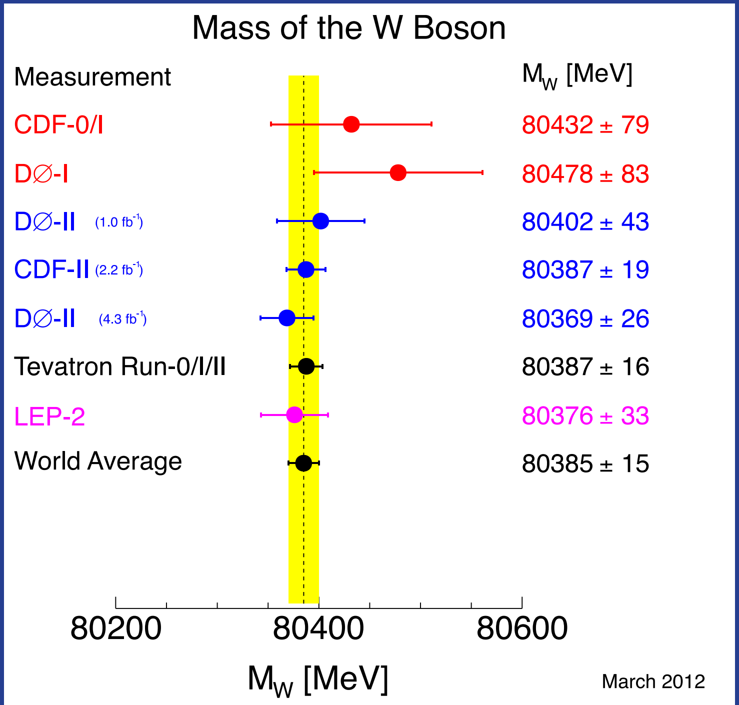


- Tevatron data are incompatible with background-only hypothesis
  - Full combination, p-values are 3.0σ local or 2.5σ with LEE
  - Higgs to bb channels only p-values are 3.3σ local or 3.1σ with LEE
  - *Evidence-for paper in bb channels published – PRL 109,071804*
- Tevatron data are compatible with S.M. Higgs 115 < $m(H)$ < 140 GeV

$m(W)$

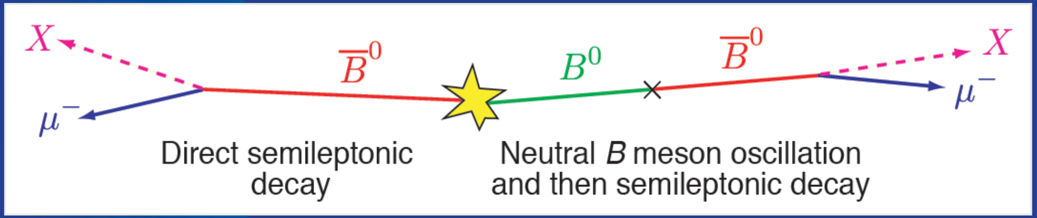
Critical test of S.M.



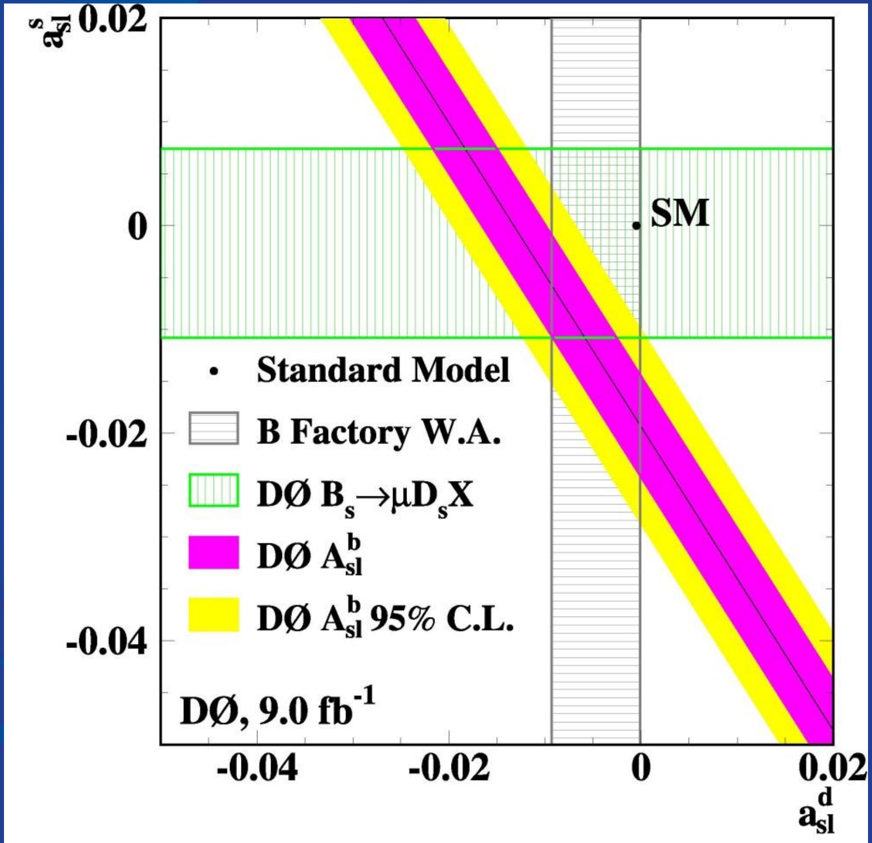


- **Requires a *very* good understanding of calorimetry**
- $M_W = 80.375 \pm 0.023$ GeV
  published in April 2012, Phys. Rev. Lett. 108, 151804

Dimuon Charge Asymmetry



$$A_{sl}^b \equiv \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}}$$



$$A_{sl}^b = \left[-7.87 \pm 1.72_{STAT} \pm 0.93_{SYST}\right] \times 10^{-3}$$

~3.9 σ deviation from SM prediction of $0.23^{+0.05}_{-0.06}$ x10^{-3}

Phys. Rev. D 84, 052007 (2011)

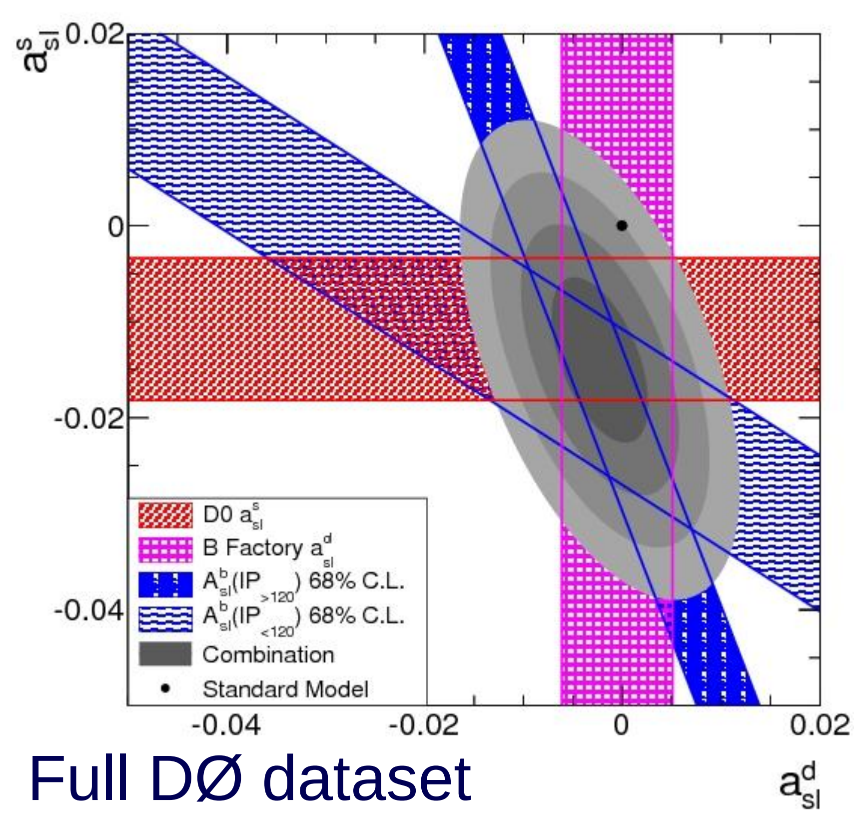
Dimuon Charge Asymmetry

To pick out the B_S component, measure $B_S \to \mu D_S X$ asymmetry

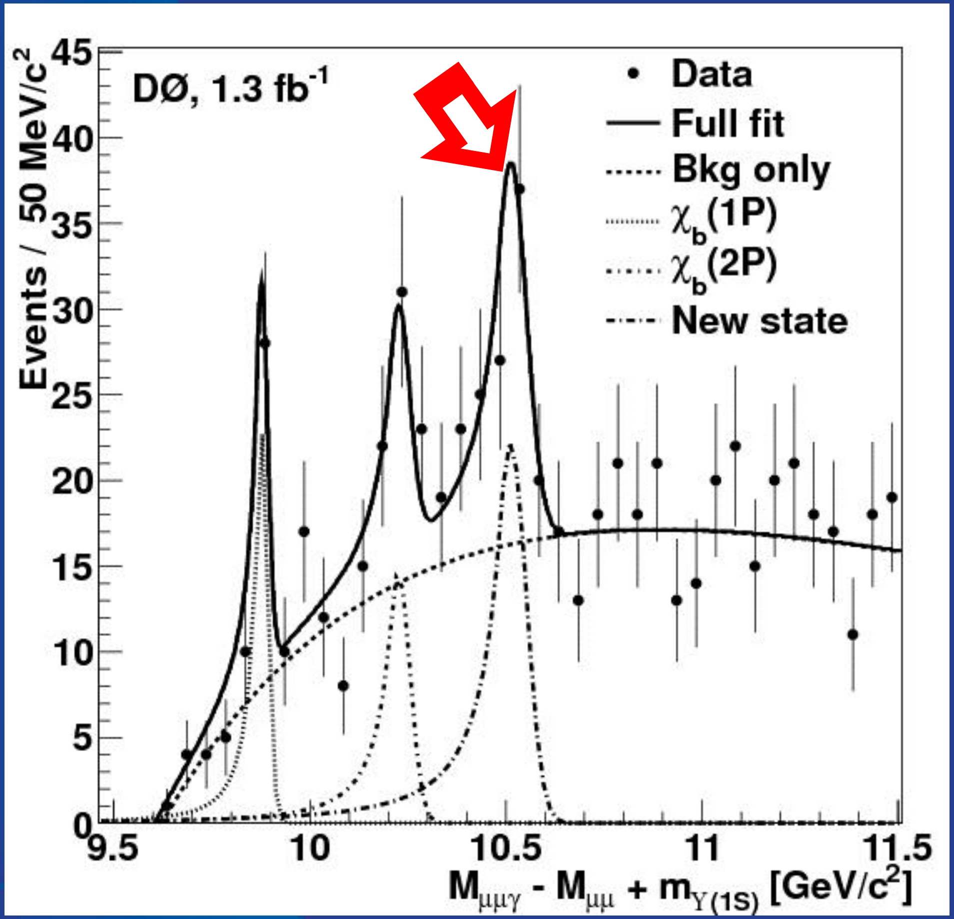
$$a_{sl}^{s} = \left[-10.8 \pm 7.2_{STAT} \pm 1.7_{SYST}\right] \times 10^{-3}$$

submitted to PRL; arXiv:1207.1769

To pick out the B^0 component, measure $B^0 \to \mu D^{(*)} X$ asymmetry - should be out very soon



$\chi_b(3P)$



An example of rapid response to LHC results

21 Dec 2011: ATLAS claims signal for $\chi_b(3P)$ in $\Upsilon(1S,2S)\gamma$

13 Apr 2012: DØ confirms signal for "$\chi_b(3P)$" in $\Upsilon(1S)\gamma$

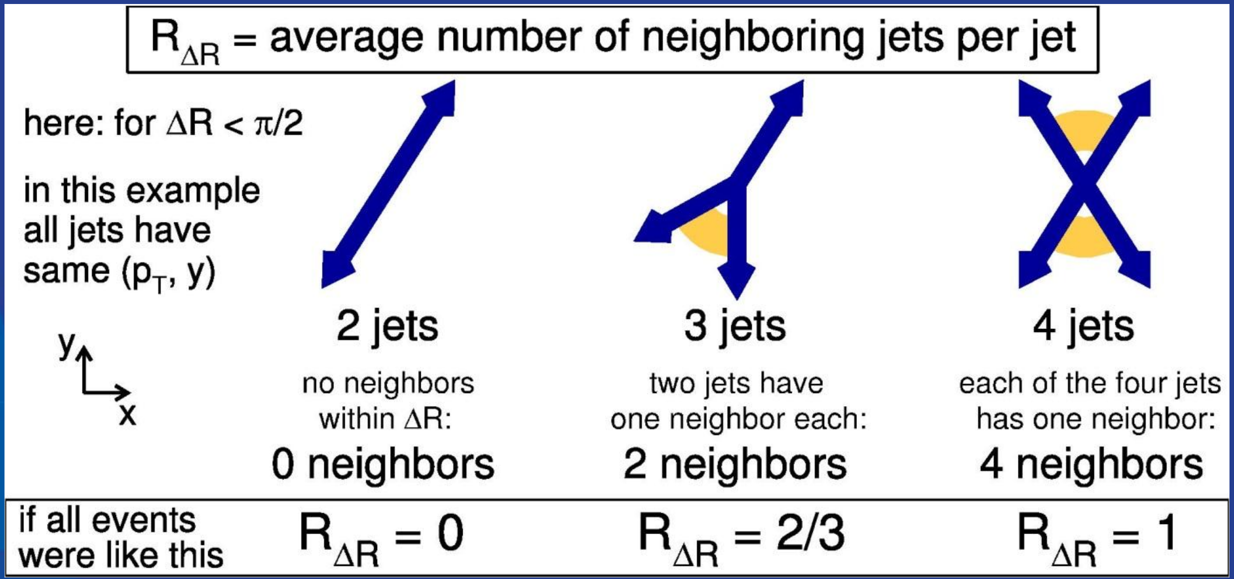
$(\Upsilon\to\mu\mu,\ \gamma\to ee)$

Running of α_S

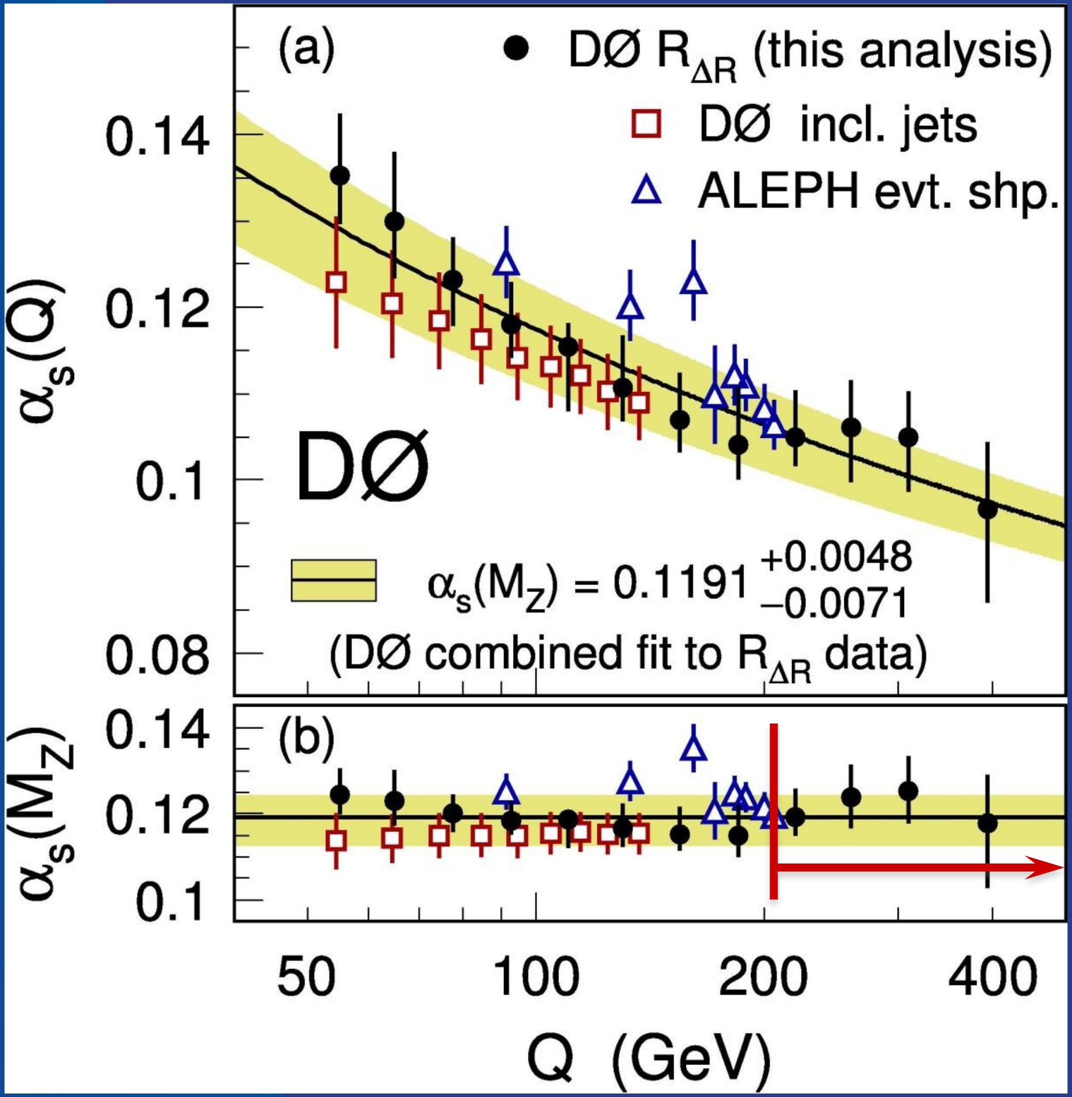
Previous “demonstrations” of running of α_S beyond LEP II energies based on inclusive jet production measurements.

But running of α_S is used in construction of parton density functions used in computing inclusive jet production rates as function of α_S.

New observable $R_{\Delta R}$ has little dependence on parton density functions.

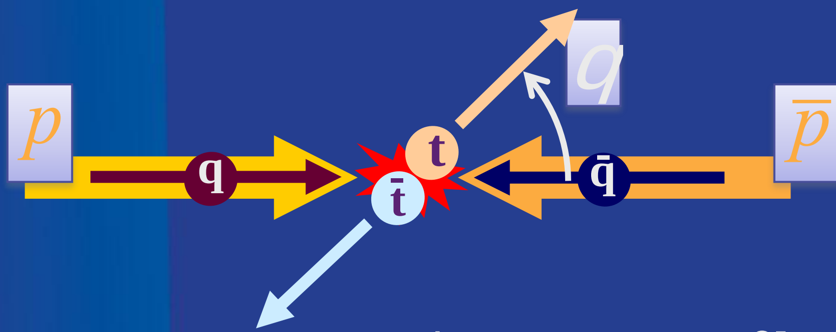


Running of α_s

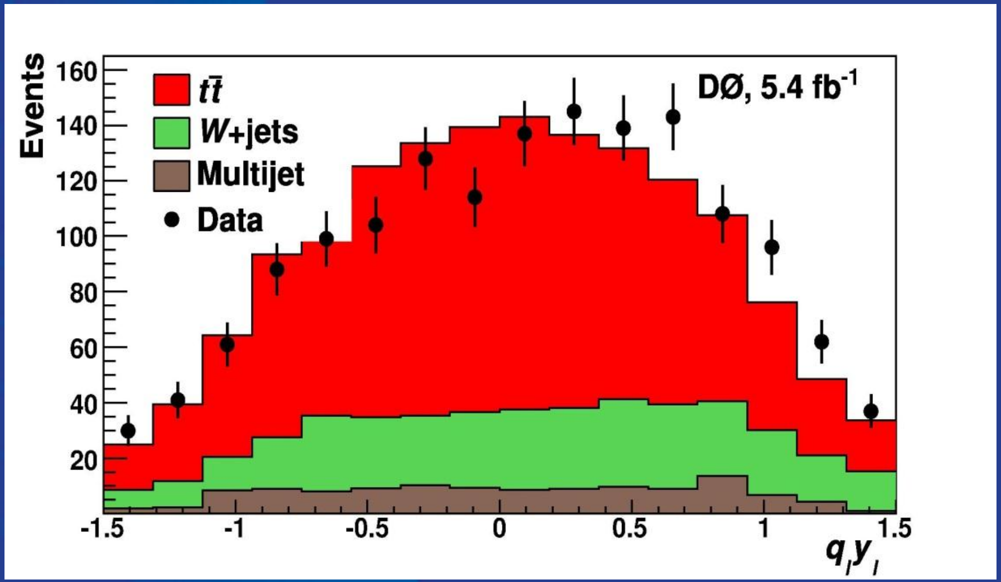


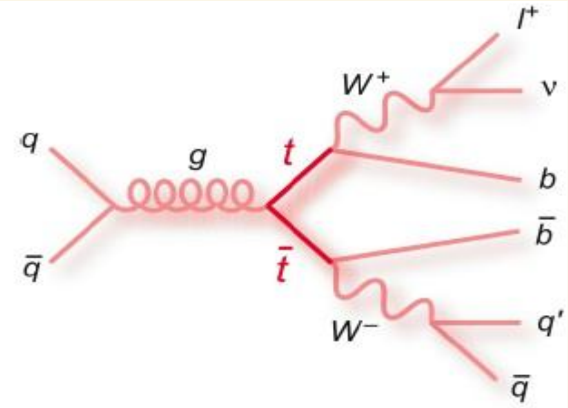
First test of Renormalization Group Equations at momentum transfers above 208GeV

Top pair production asymmetry $A_{\mathrm{FB}}(t)$



$\theta < \pi/2$ more common than $\theta < \pi/2$ at $\mathcal{O}[\alpha_S^3]$





In "lepton+jets" with reconstructed tt directions, measured asymmetry of (9.2 ± 3.7)%, vs. prediction of (2.4 ± 0.7)% from MC@NLO

Using lepton only, measured (14.2 ± 3.8)%, vs prediction (0.8 ± 0.6)%

Phys.Rev.D 84, 112005 [5.4fb^{-1}]

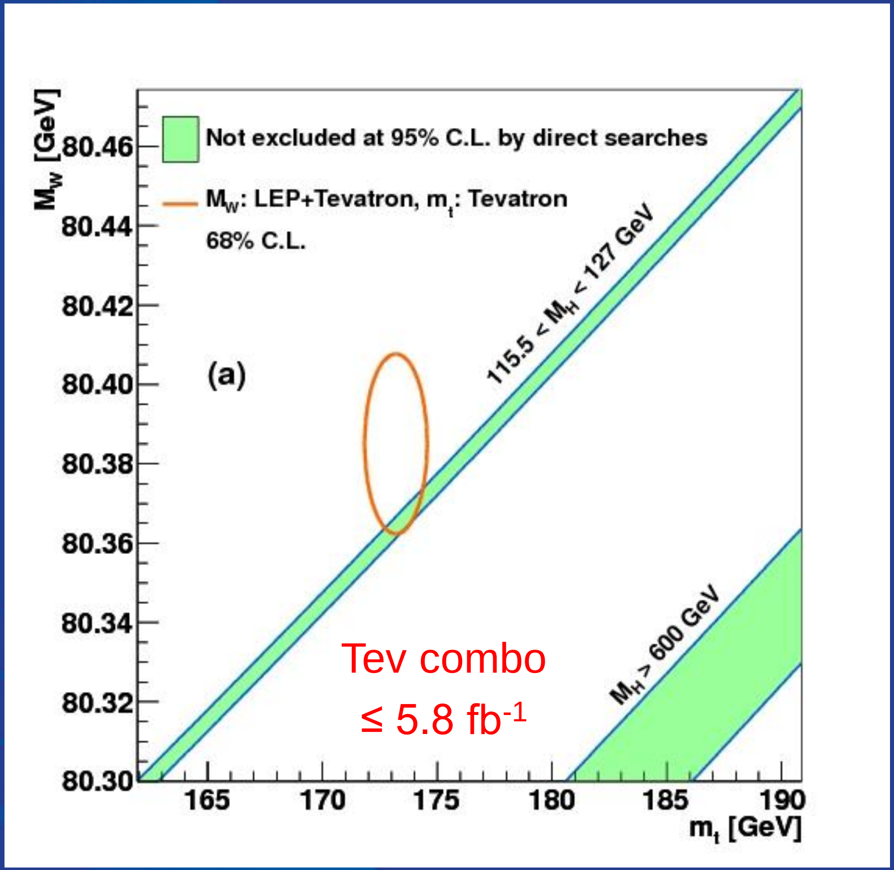
Top pair production asymmetry $A_{FB}(t)$

TABLE III. Reconstruction-level A_{FB} by subsample.

	A_{FB} (%)	
Subsample	Data	MC@NLO
$m_{t\bar{t}} < 450$ GeV	7.8 ± 4.8	1.3 ± 0.6
$m_{t\bar{t}} > 450$ GeV	11.5 ± 6.0	4.3 ± 1.3
$\|\Delta y\| < 1.0$	6.1 ± 4.1	1.4 ± 0.6
$\|\Delta y\| > 1.0$	21.3 ± 9.7	6.3 ± 1.6

$m(t)$

Critical test of S.M.



Recent result in dilepton channels – high purity sample (332 events from 4.3 fb^{-1})

Major uncertainty is mapping reconstructed jet to initial parton energies

Reduced by looking at 2 jets from W in lepton+jets channels

$$m(t) = 174.0 \pm 2.4_{STAT} \pm 1.5_{SYST} \text{ GeV}$$

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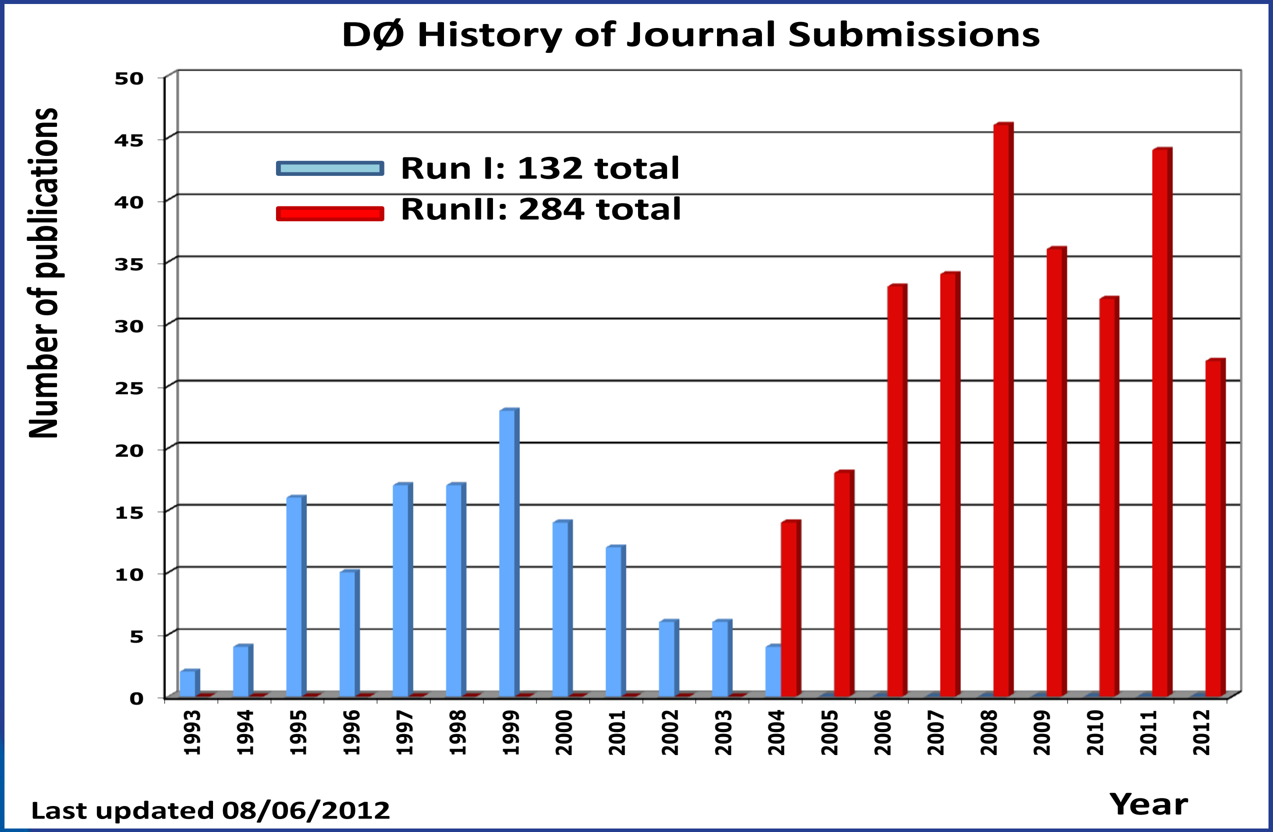
ANALYSIS PLANS

Physics Results vs Time



- Certain analyses are unique either because of $\sqrt{s}$ or $p\bar{p}$
- Plan to complete these unique and legacy measurements in next 2 years

Plans by subgroup

Higgs: Publish & document what was done for SM
Complete MSSM Higgs in bbb

New Phenomena: Nearly completed; future NP results will be folded into analyses in other groups

EW: 11 more analyses to finish
$m(W)$ will be the last – summer 2013 or later

b Physics: 5 analyses to in next 6-12 months

QCD: 19 analyses under way
All should be done by end CY 2013

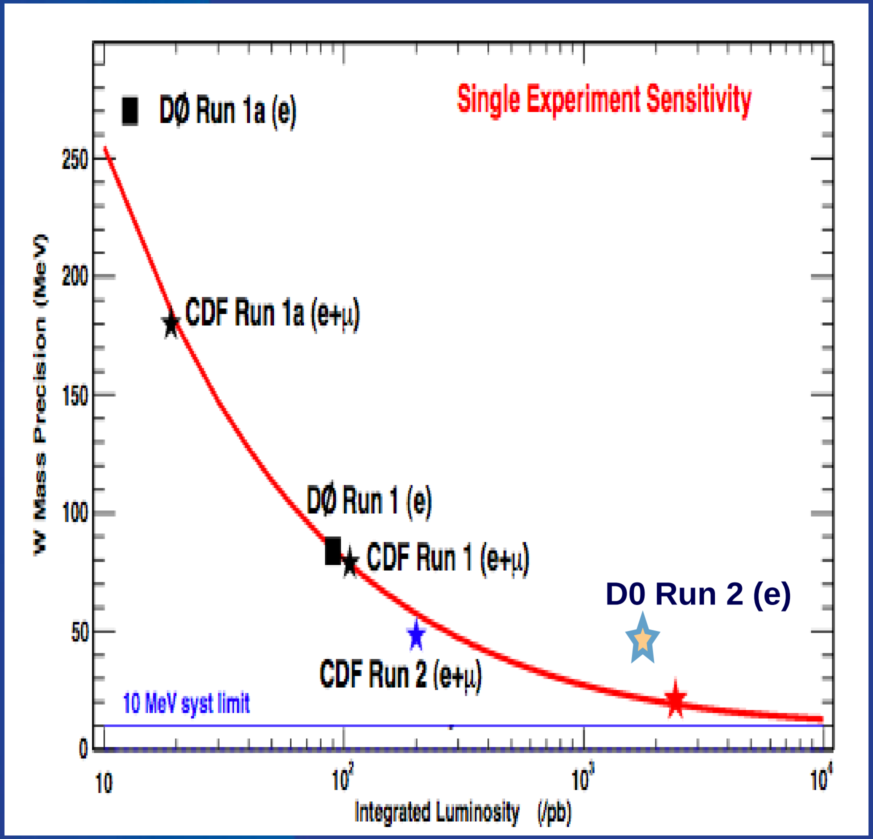
Top: 11 more analyses to finish, all by summer 2013

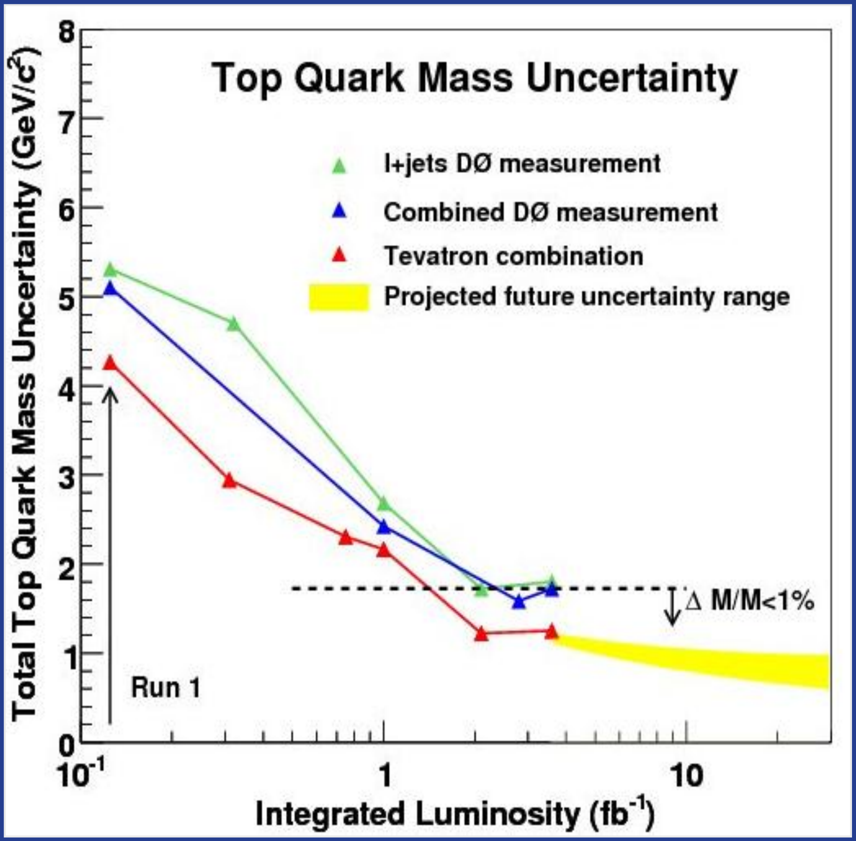
Algorithms / Technical: 4 publications in next 6-12 months

D0 publication plans by subfield

As of 27 Aug 2012	Submitted	In preparation (expect to submit in 3 months)	Expect to submit in 3-12 months	> 1 year	Totals
Higgs	5	8	0	0	**13**
NP	1	2	0	0	**3**
EW	0	2	7	2	**11**
b Physics	2	2	5	4	**13**
QCD	1	5	8	5	**19**
Top	2	1	8	0	**11**
Combo	2	1	6	3	**12**
Algo/Tech	1	0	3	0	**4**
Totals	**14**	**21**	**37**	**14**	**86**

Highlights of analysis plan - Masses





- W boson mass uncertainty ~15 MeV with full data set
- Top quark mass uncertainty better than 0.5%

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Highlights of analysis plan – *b* Physics

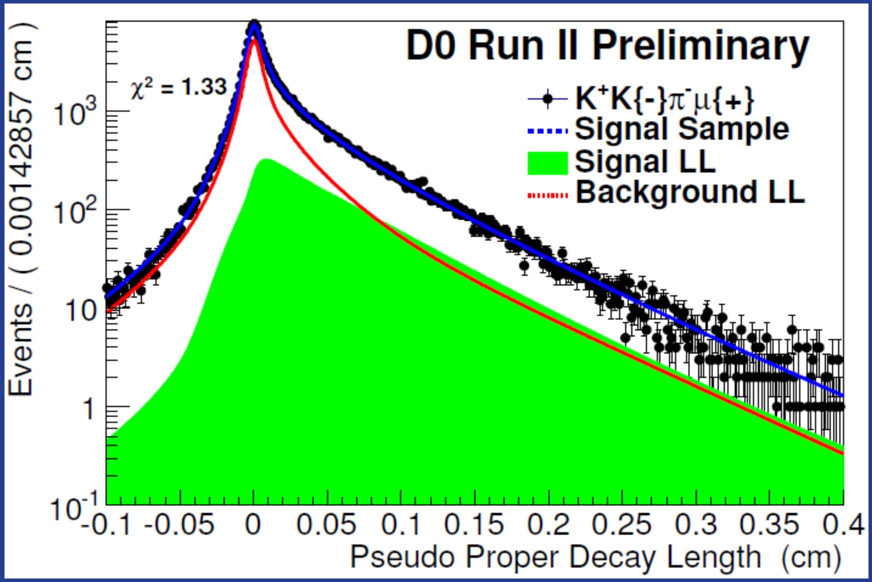
Full-dataset dimuon asymmetry result will have:

- Detector asymmetries vs. p_T and η of μ
- Improved use of p_T (μ) from muon system toroid

Should be out within a few months

B_S Lifetime

- Updated to full dataset;
- Expect ±1.9%;
  World Average is ±2.9%



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Highlights of analysis plan – Tevatron Combinations

Recently published / submitted:

1. $H \rightarrow bb$	Phys. Rev. Lett 109,071804
2. MSSM Higgs to bbb (≤5.2fb^{-1})	submitted Phys. Rev. D
3. $m(t)$	submitted Phys. Rev. D
4. W helicity in top decays	Phys. Rev. D **85**, 071106

In progress / expected < 12 months:

1. Combination of all Higgs searches from the Tevatron (in progress)
2. $m(W)$ (Phys. Rev. Lett. based on March 2012 results)
3. $A_{\mathrm{FB}}(t)$ (as soon as full data set DZero results are ready)
4. Top pair production cross section (in progress)
5. $m(t)$
6. Single top: s / t channel cross sections, V_{tb}
7. MSSM Higgs to bbb (on full dataset)

Highlights of analysis plan – Combinations

Using 10fb^{-1} (longer term / tentative):

1. $m(W)$ on full dataset — for Phys. Rev. Lett.
2. $m(t)$ on full dataset with LHC — for Phys. Rev. Lett.
3. $H \rightarrow bb$ (combination with LHC)

DATA PRESERVATION

Preserving analysis capabilities

Need a working tool, not a museum piece

D0 is part of the ICFA Study Group on Data Preservation and Long Term Analysis in High Energy Physics

Status report arXiv:1205.4667 lists seven different publications from archived data since 2009

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Publication is preservation

Preserving analysis capabilities

Plan to maintain access to

- data
- analysis software & tools
- MC generation code
- internal web / wiki pages
- internal meeting agendas
- databases etc

for 5 years after end of data taking

Internal D0 notes to be archived on INSPIRE at end of analysis efforts

Internal D0 task force has studied each type of code or data in our system for long-term solutions

Potential disruptions:

- Scientific Linux v5 going obsolete
- End of life for existing batch systems

CD has open positions for data preservation effort

DECOMMISSIONING

Decommissioning events

Special study runs

- 3 month cosmics run
- calorimeter HV study
- SMT annealing study (Abstract L9.00001 April APS 2012)

Stabilize, secure and shut down cryo & other systems

- LAr transferred, Jan 2012
- LHe to solenoid, photodetectors off Jan 2012
- LCW cooling water shutdown
- SMT chiller shutdown and drained

No safety incidents at all in decommissioning

Decommissioning events

Save / reuse valuable components:

- 2/3 of online computing (L3 farm) re-allocated to analysis use – rest was kept for cosmics
- 11,000 gal of pure LAr surveyed for activity and stored on-site
- Muon readout electronics return to home institutes for other experiments
- Some HV, blowers, single board computers re-usable
- Cryo components & instrumentation re-usable

Reuse floor space in D0 Hall

MicroBooNE LAr TPC being assembled in tent in D0 Assembly Hall high bay

COUPP, g-2, MINERνA, NOνA also using space in D0 Assembly Hall

Exhibit for visitors

"I hear and I forget. I see and I remember . . ." Confucius

Relocated display of "artifacts" – i.e. scintillator and silicon microtracker pieces etc. to larger 1st floor area

Moved magnet iron, forward calorimeter to improve visibility of inner detector & make for safe touring

Screen captures recreate displays during running

> 650 visitors since 1 Feb 2012;

> 130 saw also the Tevatron itself

SUMMARY

D0 Summary

- One year after end of data-taking D0 remains a very active collaboration with high publication rate
- We expect that this will continue until summer 2013
- Combination papers with CDF or LHC will follow as inputs available
- Practically all planned analyses will be published by late 2014
- Data analysis capability maintained until ~2016
- Reuse of D0 facilities for other experimental efforts has begun
- Visitor’s exhibit area popular, educational

SUPPORTING MATERIAL

Tevatron Physics Goals

Precision study of the Standard Model
- Weak bosons, top quark, QCD, B-physics…

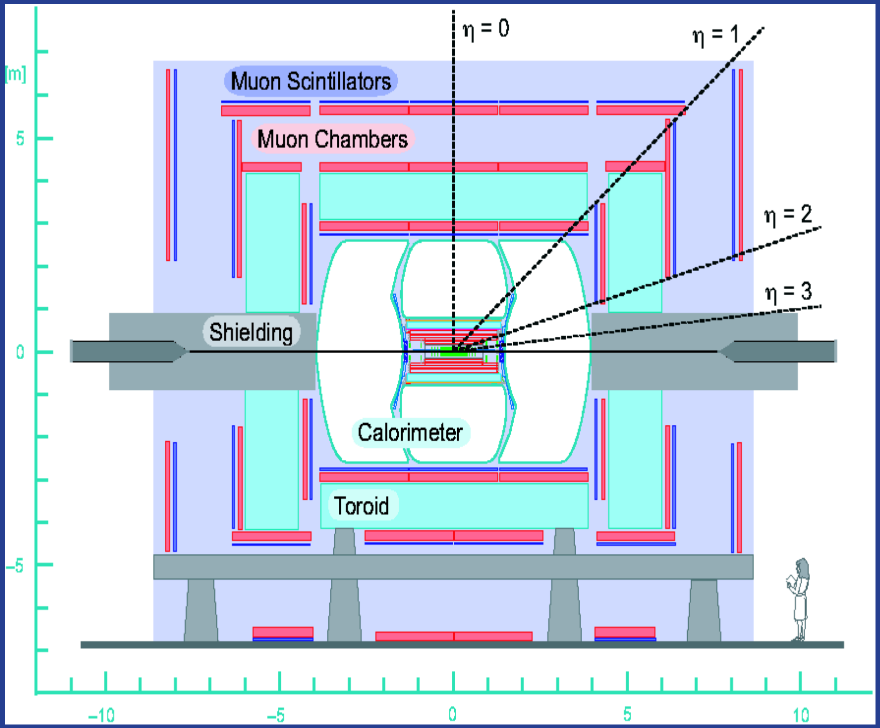
Search for particles and forces beyond those currently observed
- Higgs, supersymmetry, extra dimensions, un-expected…

Driven by these goals the experiment emphasizes

Electron, muon and **tau** identification

Jets and **missing transverse energy**

Flavor tagging through **displaced vertices**



Probing fundamental physics questions

Quark sub-structure?

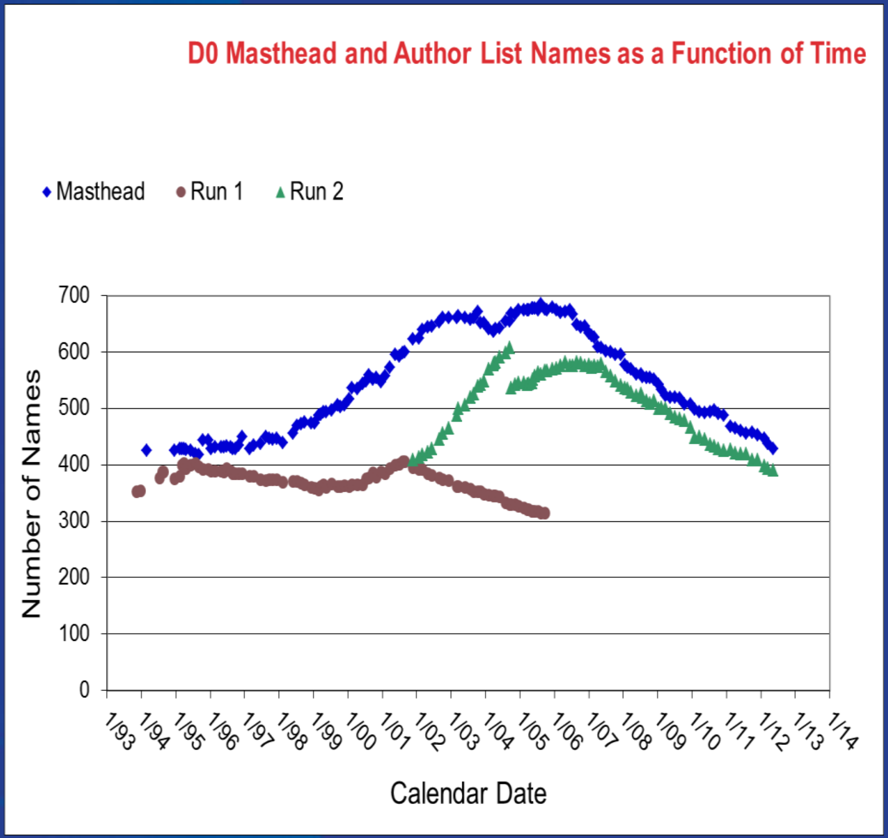
Origin of mass?

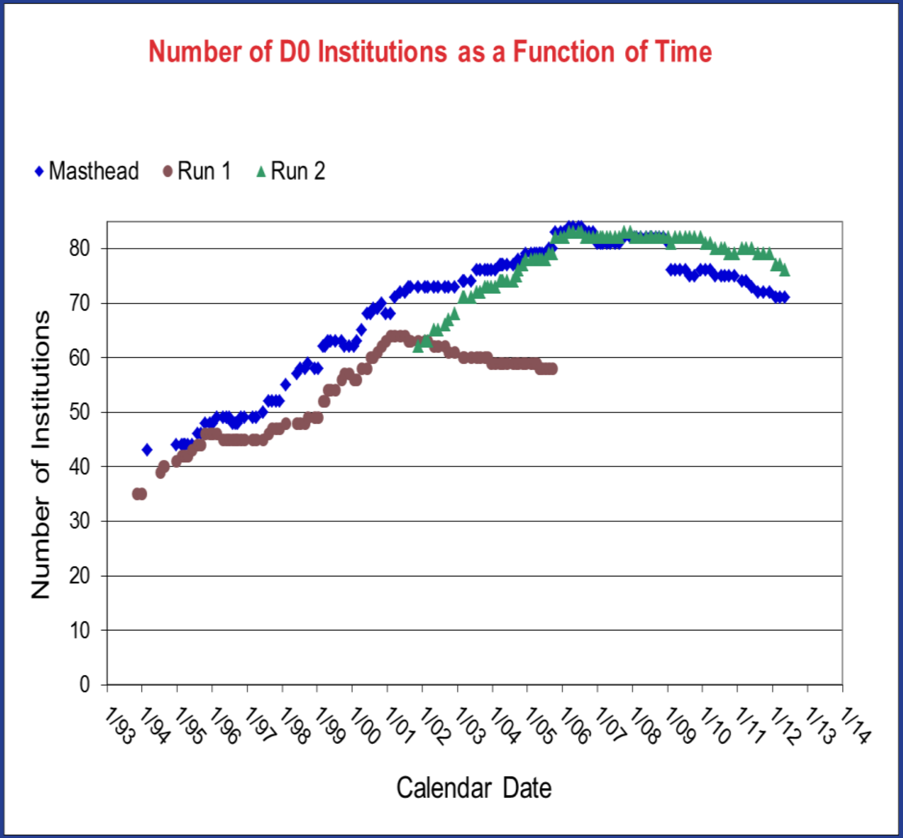
Matter-antimatter asymmetry?

What is cosmic dark matter? SUSY?

What is space-time structure? Extra dimensions?…

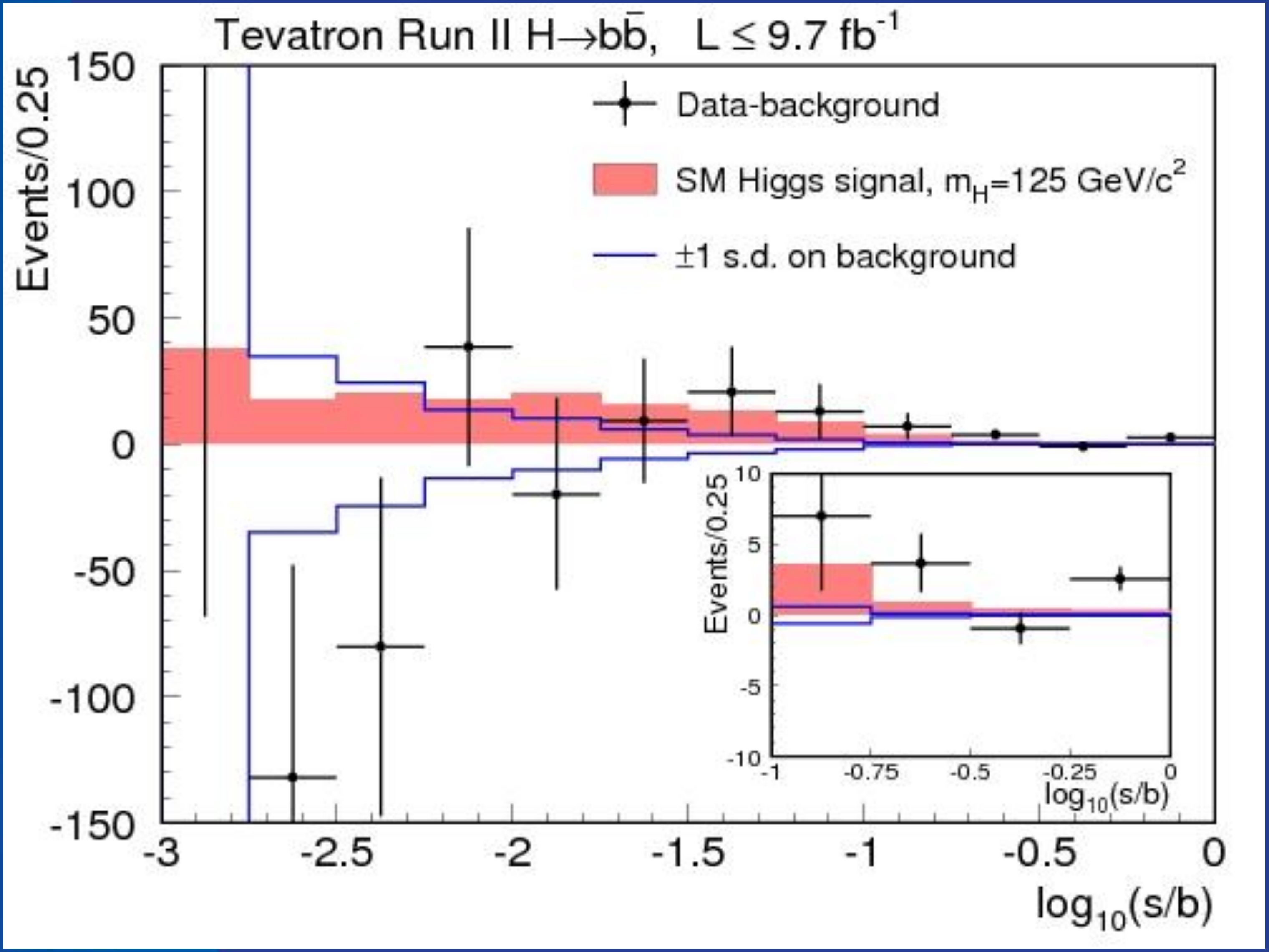
Collaboration size vs time





- **Experiment membership is declining about ~5 or 6% per year**
- **Number of university groups is steady**
- **16 students, 1 postdoc joined in past year (10+1 from Kiev)**

Some title



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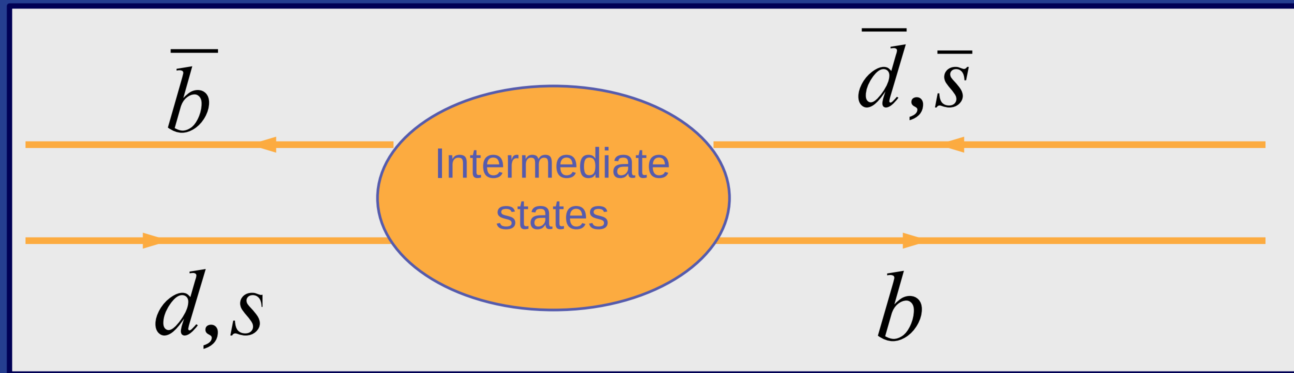
Neutral Meson Mixing Reminder

$\Sigma q = 0$

$\Sigma Y = 0$

colorless

$f \,\&\, \bar{f}$



$$i \frac{\partial}{\partial t} \begin{bmatrix} |B^0\rangle \\ |\bar{B}^0\rangle \end{bmatrix} = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix} \begin{bmatrix} |B^0\rangle \\ |\bar{B}^0\rangle \end{bmatrix}$$

To get $H_{12} = M_{12} - (i/2)\Gamma_{12}$ right, you need to know all the intermediate states; and if you got H_{12} wrong, there might be new-physics intermediate states that you don't know about!

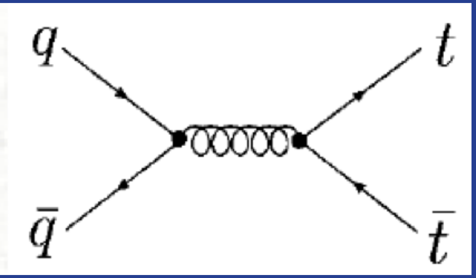
If $arg(\Gamma_{12}/M_{12}) \neq 0$, rate $(B^0_{d,s} \rightarrow \bar{B}^0_{d,s}) \neq$ the rate $(\bar{B}^0_{d,s} \rightarrow B^0_{d,s})$

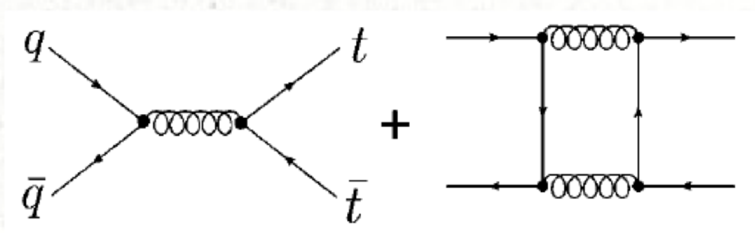
$$\text{Then} \quad \frac{\Gamma\left(\bar{B}^0_q \rightarrow \mu^+ X\right) - \Gamma\left(B^0_q \rightarrow \mu^- X\right)}{\Gamma\left(\bar{B}^0_q \rightarrow \mu^+ X\right) + \Gamma\left(B^0_q \rightarrow \mu^- X\right)} \neq 0$$

Inclusive muon charge asymmetry

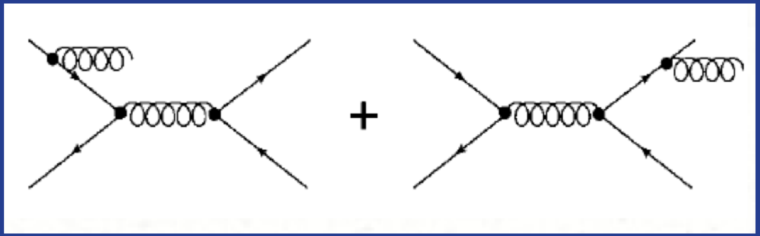
$A_{FB}(t)$ Predictions

At order α_S^2, $A_{FB} = 0$





$A_{FB} > 0$



$A_{FB} < 0$

Kuhn and Rodrigo, PRL 81, 49 (1998)	$A_{FB} = 5\%$
Ahrens et al arXiv:1106.6051:	$A_{FB} = 7.3\%$
Hollik and Pagani arXiv:1107.2606:	$A_{FB} = 9.0\%$

t decay modes