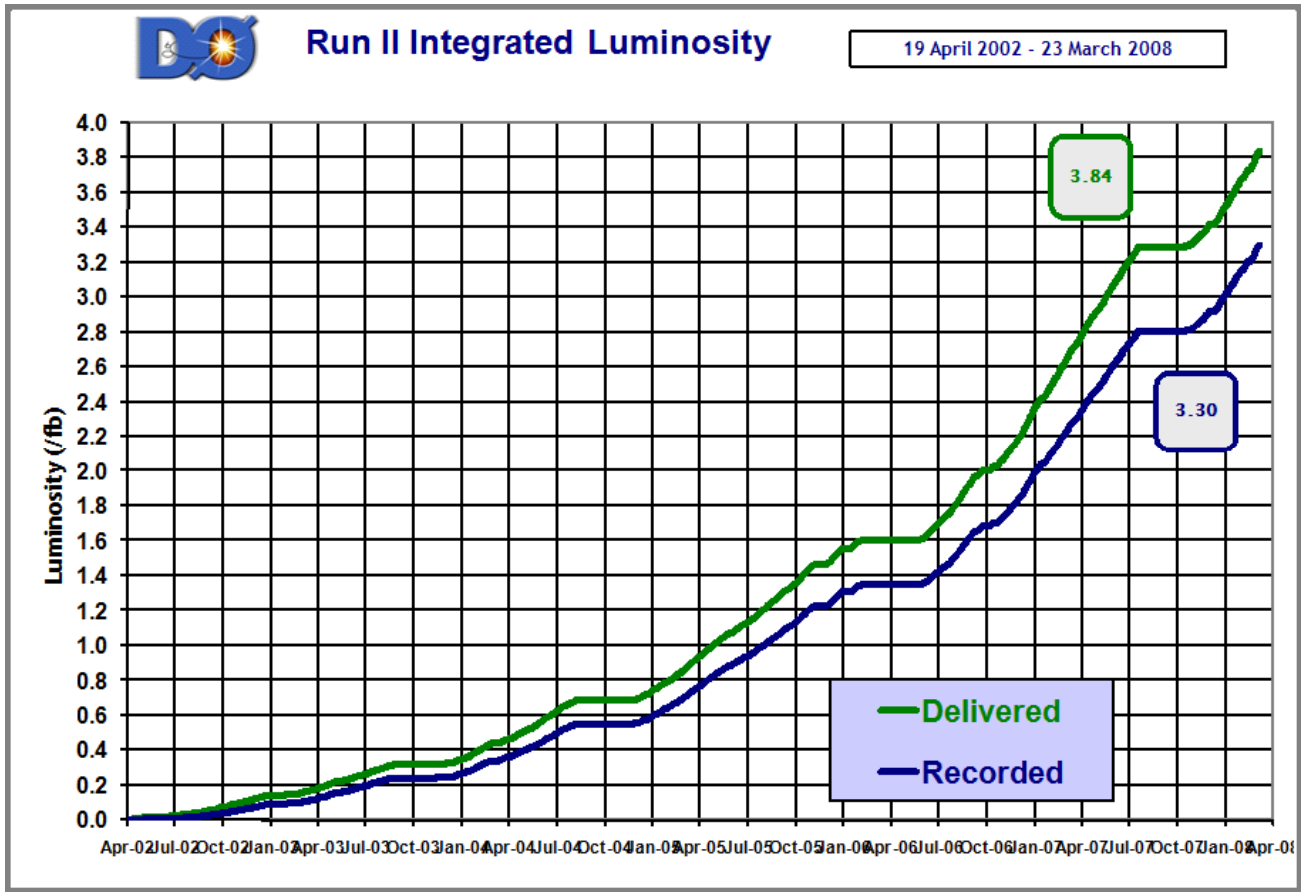
Status of the DØ Experiment

Erich W. Varnes
University of Arizona
for the
DØ Collaboration

Physics Advisory Committee Meeting
March 28, 2008

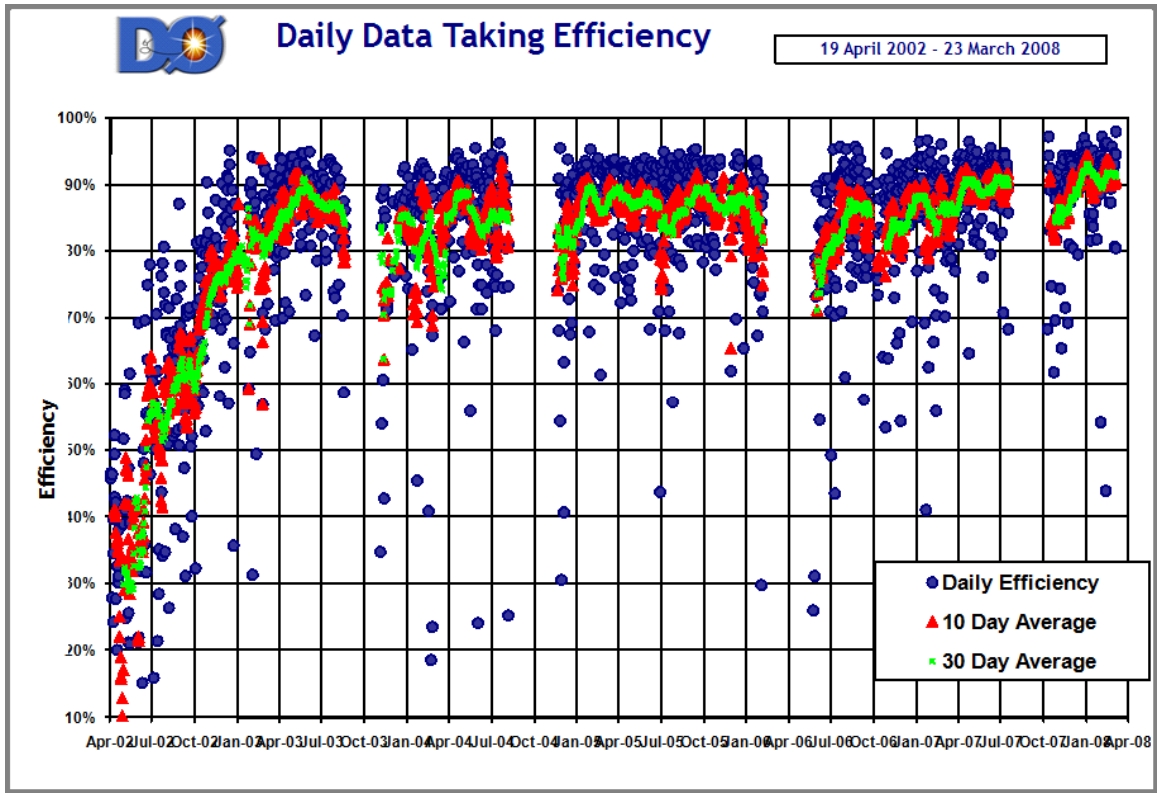
Integrated Luminosity



3.3 fb^{-1} recorded
0.5 fb^{-1} since last PAC meeting

Congratulations to Accelerator Division for recent records in anti-proton stacking, peak L, and L/week!

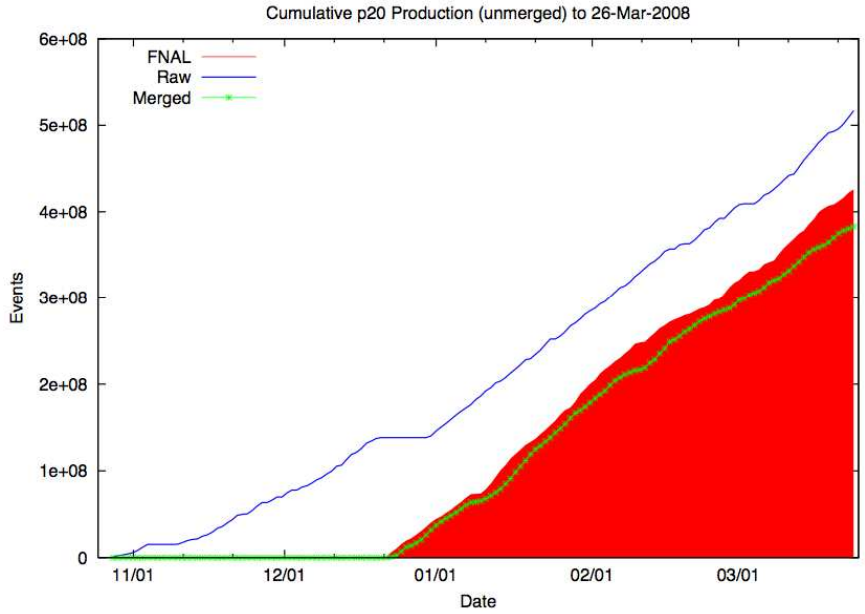
Data-taking Efficiency



- Exceptional reliability
  - we are operating at >90% 30-day average efficiency
  - thanks to dedicated experts and control room shifters
- No known issues with detector elements in the short or long term

- New version of trigger list deployed March 14th
  - gives better yield and lower deadtime at high luminosity
  - this is the last major change to our trigger

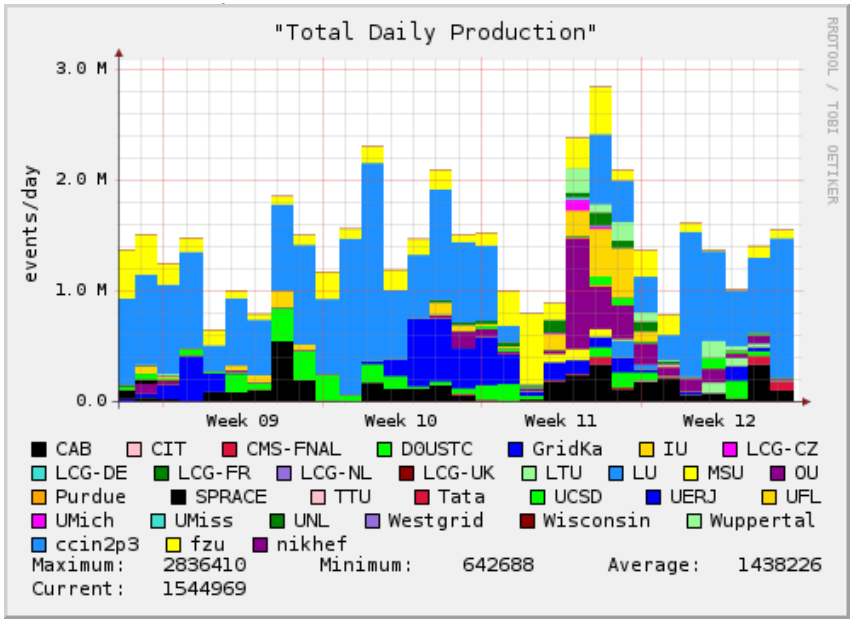
Raw Data Reconstruction

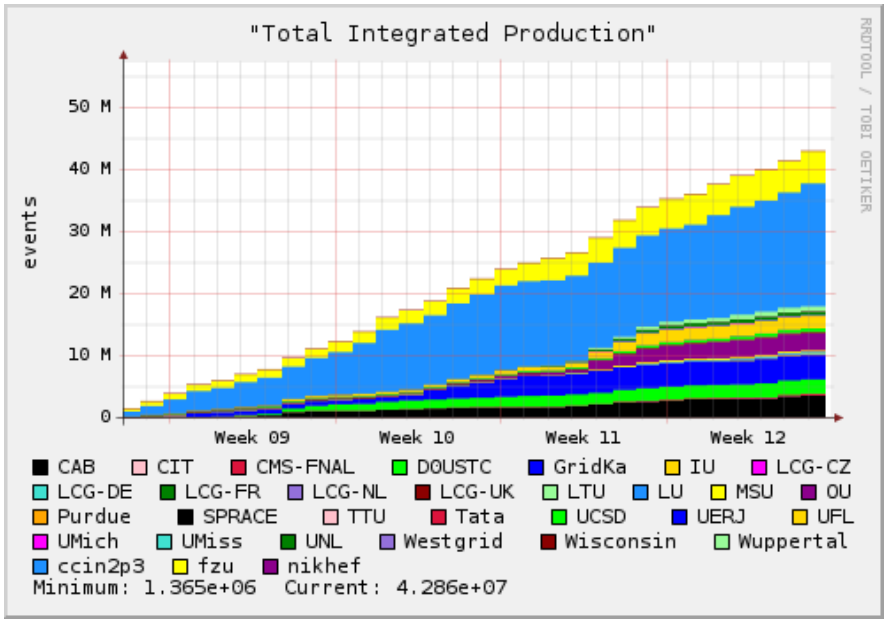


- We use DØ-controlled resources only, but access them via grid interface
  - allows seamless access to larger CPU pool should the need arise (e.g. remote sites were used for major reprocessing effort in 2007)
- Bringing this system to a production level of stability has been a major successful project in the Computing Division

MC Production

- We use a detailed GEANT simulation with zero-bias events from data overlaid
- Exploit the grid to maximize CPU power
  - ccin2p3, OSG, GridKa, LCG -- opportunistic use of CPU at many remote





Typically produce 10-15 million events/week

Collaboration Manpower Analysis

- Estimates of available full-time-equivalent physicists (FTE's) are obtained from an analysis of the Memoranda of Understanding (MoU's) submitted by each institution on DØ
  - MoU's completed in 2005 covered 2005-2007 period, completed early 2007 covered 2007-2009 period
- One-year overlap in each set of MoU's gives us a means to have continuous predictions and monitor changes in expectations

Physicist FTE's	2005	2006	2007	2008	2009
2005-2007 MoU data	474	437	354		
2007-2009 MoU data			357	272	184
Needs (excluding analysis)	230	200	165	145	124

P5 in June 2007 used above data to endorse 2009 run of the Tevatron

Collaboration MOUs

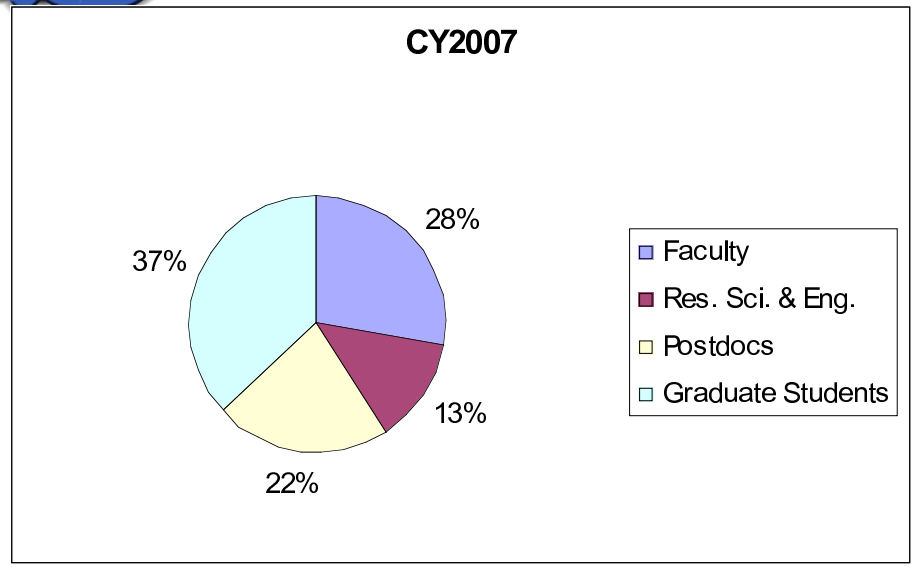
• Currently finishing collection of MOU's covering 2009-2011 period. Results available to date are tabulated below, representing 96% of the collaborating institutions

• The corresponding 2007-2009 MOU data from the same subset of institutions are also provided below

Physicist FTE's	2007	2008	2009	2010	2011
2007-2009 MoU data **(subset)**	344	265	182		
2009-2011 MoU data **(subset)**			233	181	118

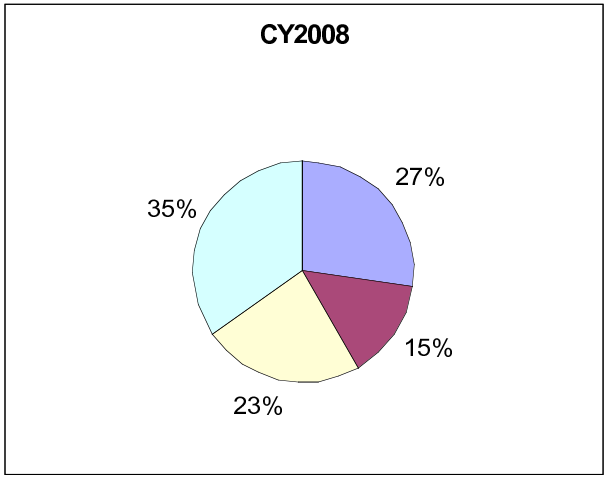
- 25% increase in 2009 FTE with respect to previous set of MoU's demonstrates the strengthened commitment of the Collaboration to continuing Tevatron program
- Preliminary estimate for 2010 manpower needs (excluding analysis) are ~100 FTE's
- Current FTE estimates for 2010 closely match previous estimates for 2009
  - Expect sufficient but lean manpower for 2010 run

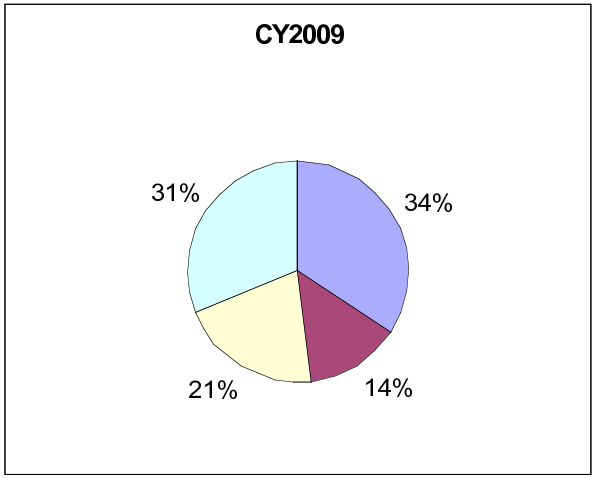
Collaboration Manpower Composition

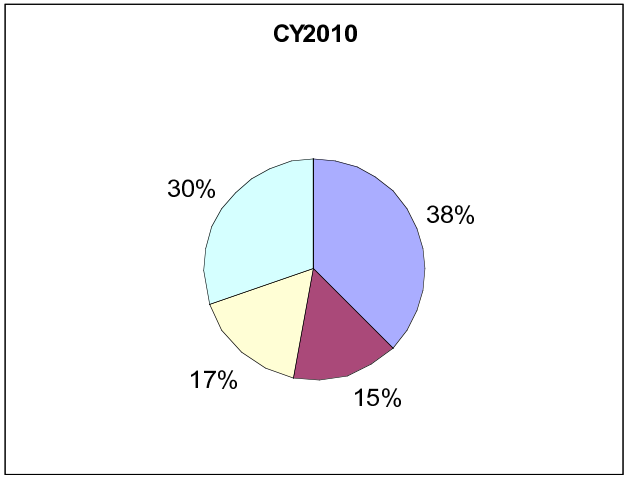


MoU's provide detailed information about composition of the DØ Collaboration manpower

- Faculty
- Research scientists
- Postdocs
- Graduate students







Composition is fairly stable and indicative of natural changes in the Collaboration at the current stage

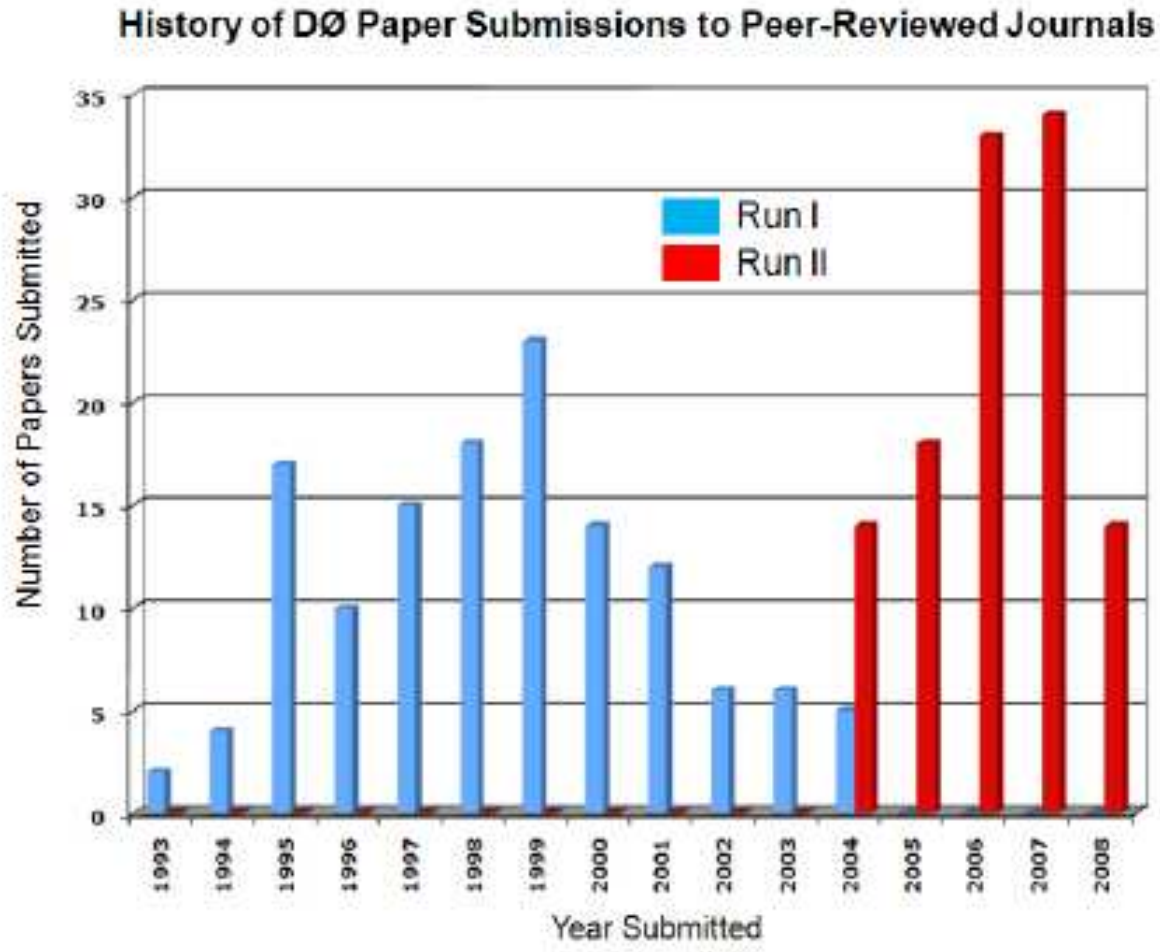
Physics Output

Since September 2007 (last PAC meeting), we have released

- 14 preliminary results
- 28 journal papers
  (~ 1/week)

covering

- QCD
- B Physics
- Electroweak Physics
- Top Physics
- Higgs Searches
- New Phenomena



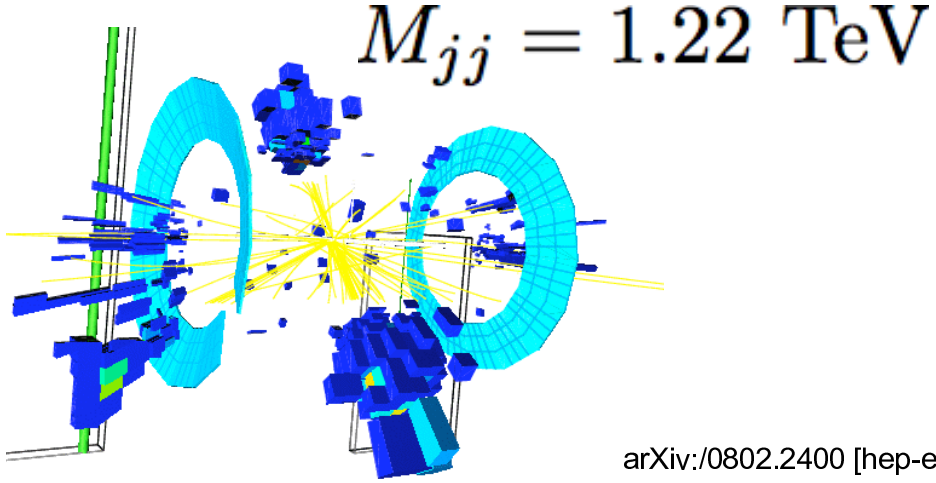
http://www-d0.fnal.gov/Run2Physics/WWW/results.htm

Recent Physics Highlights

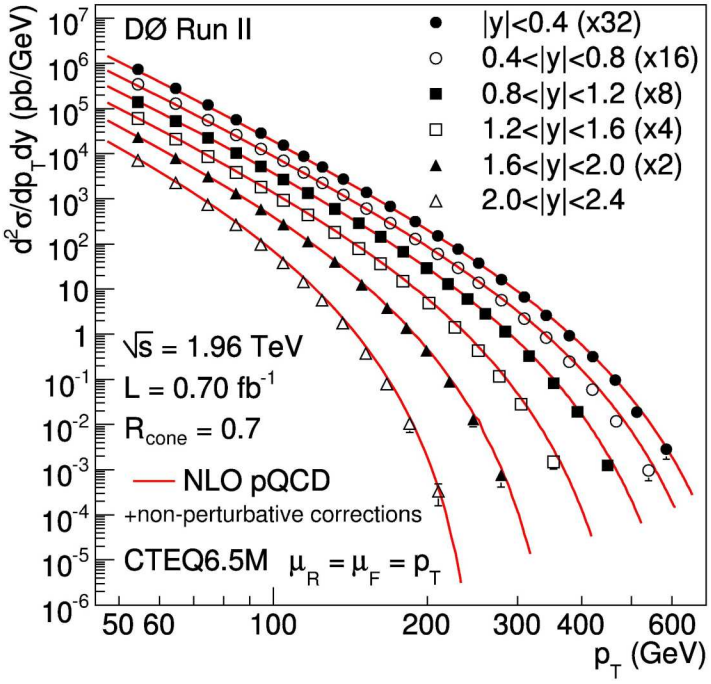
- The remainder of this talk will be a sampling of new physics results presented at Winter 2008 conferences
- Selected results:
  - inclusive jets
  - B_s mixing parameters
  - Top quark mass
  - $W\gamma$ & radiation amplitude zero
  - ZZ production
  - low and high mass SM Higgs
  - searches for squarks and gluinos
  - large extra dimensions in mono-photons

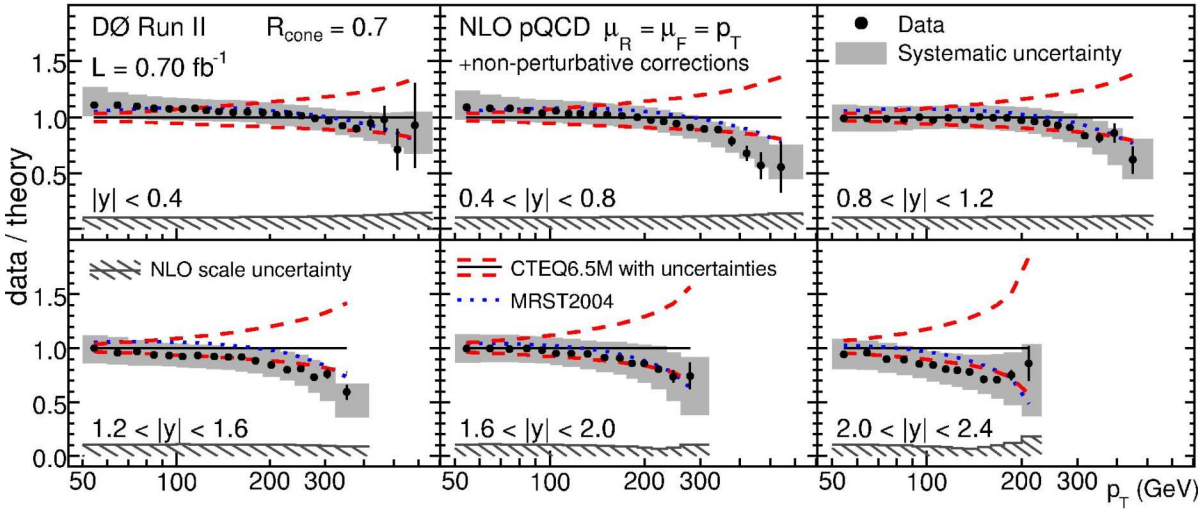
Inclusive Jet Production

- Motivation:
  - constrain PDF's
  - test QCD calculations



arXiv:/0802.2400 [hep-ex]





Most precise measurement and over widest kinematic range to date

CP-violating Phase from $B_s^o \to J/\psi\phi$

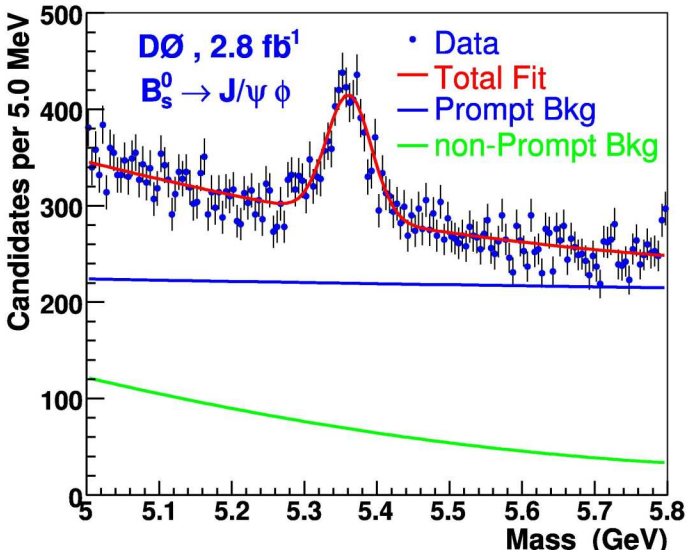
- Simultaneous unbinned maximum likelihood fit to distribution of
  - proper decay time
  - three decay angles
  - mass
- Events are flavor tagged
  - opposite and same side

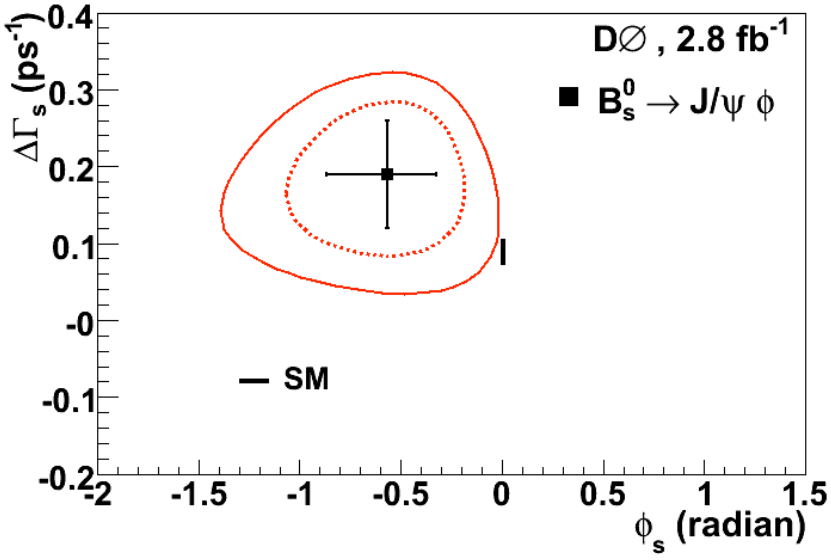
Result:

$$\phi_s = -0.57^{+0.24}_{-0.30}(\text{stat.})^{+0.07}_{-0.02}(\text{syst.})$$

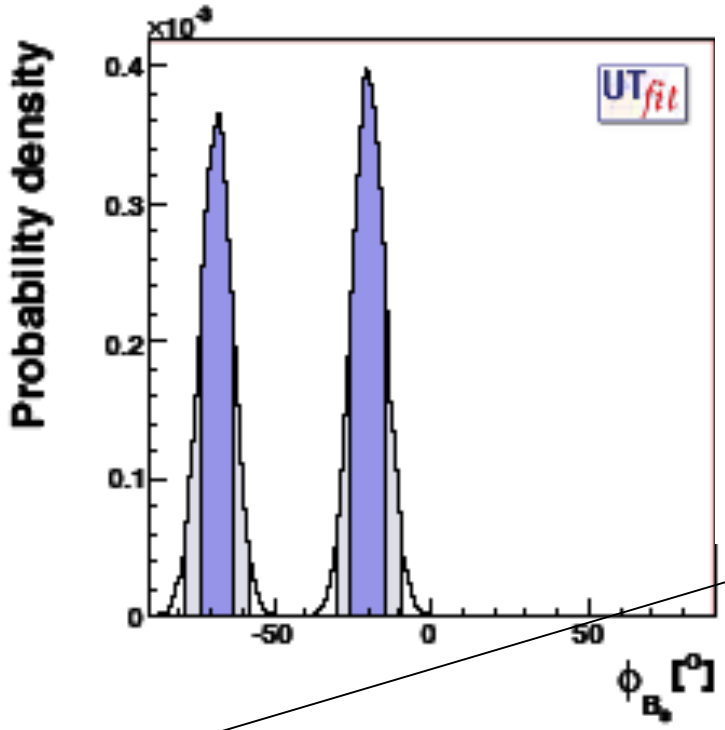
$$\phi_s(\text{SM}) = -0.038 \pm 0.002$$

SM p-value: 6.6%





A Crack in the SM?



FIRST EVIDENCE OF NEW PHYSICS IN b ↔ s TRANSITIONS

(**UT***fit* Collaboration)

M. Bona,[1] M. Ciuchini,[2] E. Franco,[3] V. Lubicz,[2,4] G. Martinelli,[3,5] F. Parodi,[6] M. Pierini,[1] P. Roudeau,[7] C. Schiavi,[6] L. Silvestrini,[3] V. Sordini,[7] A. Stocchi,[7] and V. Vagnoni[8]

[1] *CERN, CH-1211 Geneva 23, Switzerland*
[2] *INFN, Sezione di Roma Tre, I-00146 Roma, Italy*
[3] *INFN, Sezione di Roma, I-00185 Roma, Italy*
[4] *Dipartimento di Fisica, Università di Roma Tre, I-00146 Roma, Italy*
[5] *Dipartimento di Fisica, Università di Roma "La Sapienza", I-00185 Roma, Italy*
[6] *Dipartimento di Fisica, Università di Genova and INFN, I-16146 Genova, Italy*
[7] *Laboratoire de l'Accélérateur Linéaire, IN2P3-CNRS et Université de Paris-Sud, BP 34, F-91898 Orsay Cedex, France*
[8] *INFN, Sezione di Bologna, I-40126 Bologna, Italy*

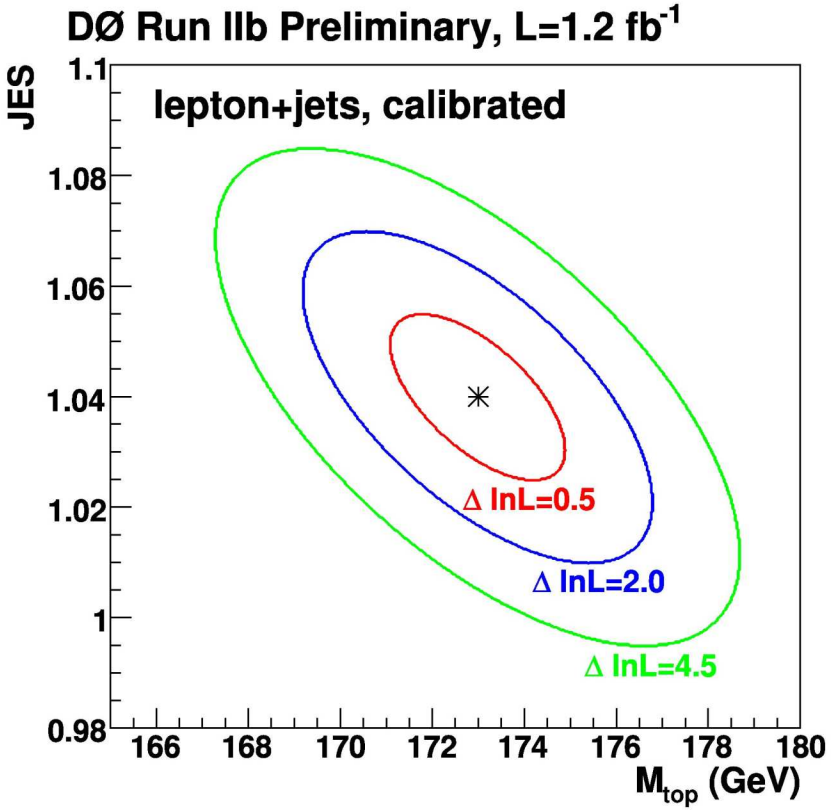
We combine all the available experimental information on B_s mixing, including the very recent tagged analyses of $B_s \to J/\Psi\phi$ by the CDF and DØ collaborations. We find that the phase of the B_s mixing amplitude deviates more than 3σ from the Standard Model prediction. While no single measurement has a 3σ significance yet, all the constraints show a remarkable agreement with the combined result. This is a first evidence of physics beyond the Standard Model. This result disfavours New Physics models with Minimal Flavour Violation with the same significance.

more than 3σ from the Standard Model prediction.

DØ continues very active studies of the heavy flavor sector

Top Quark Mass (ℓ + jets)

- Uses Matrix Element method
  - Jet energy scale fitted in situ using M_W

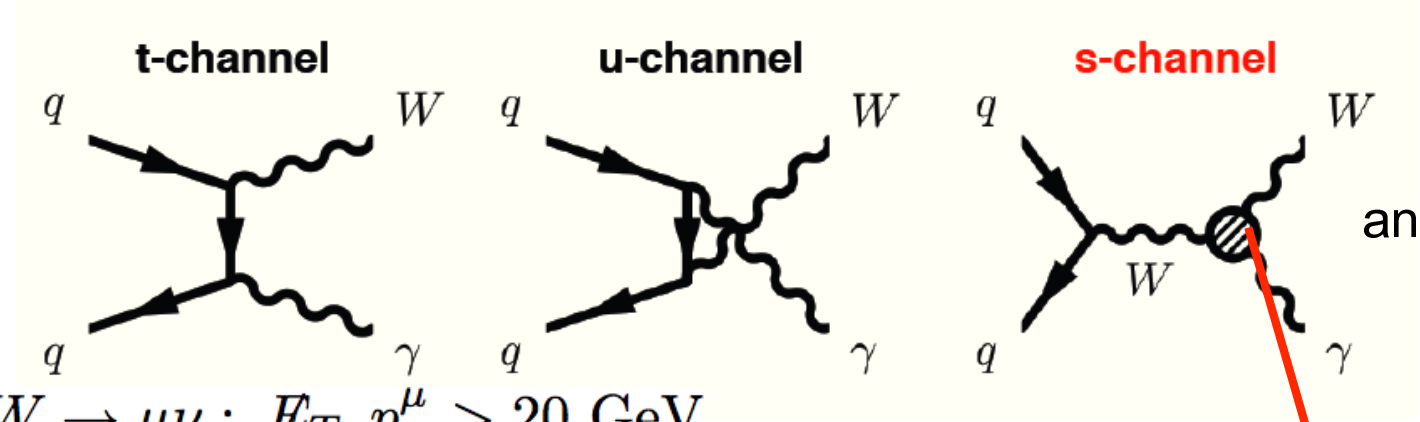


Combination of Run IIa and Run IIb measurements yields

$$m_t = 172.2 \pm 1.1(\text{stat.}) \pm 1.6(\text{syst.})$$

Total uncertainty of 1.1%
Most precise measurement to date

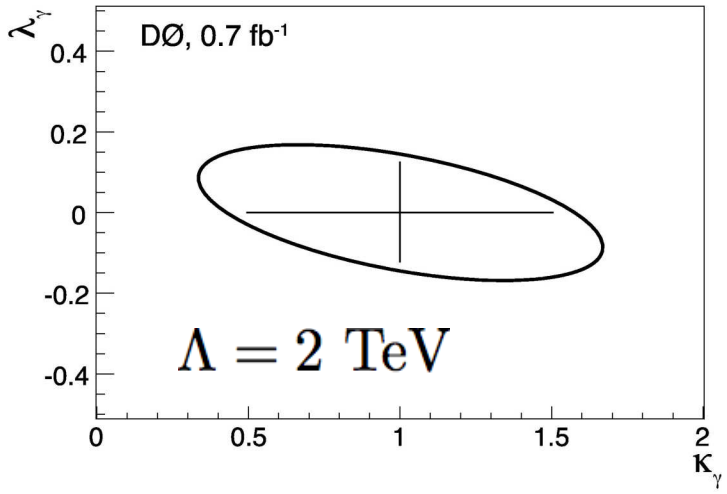
Wγ Production

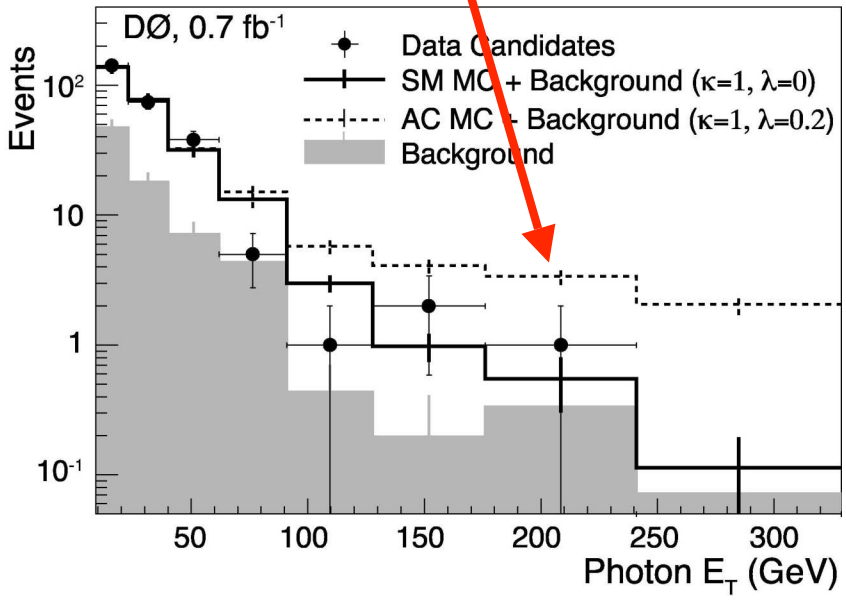


anomalous TGC

$$W \to \mu\nu : \not{E}_T, p_T^{\mu} > 20 \text{ GeV}$$

$$W \to e\nu : \not{E}_T, p_T^{e} > 25 \text{ GeV}$$

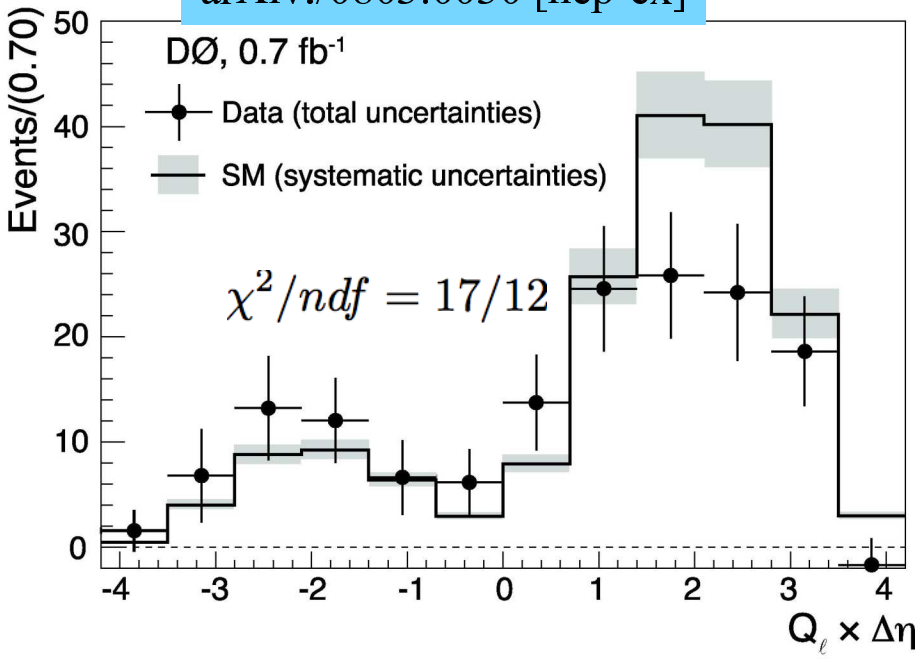




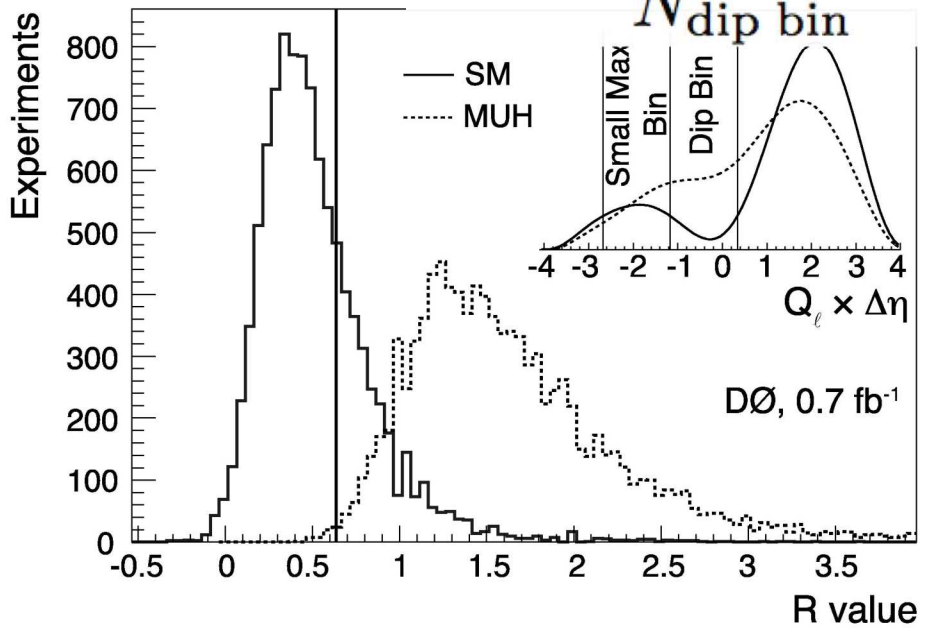
Radiation Amplitude Zero (RAZ)

- Interference between production diagrams leads to RAZ
  - manifests as a deficit of events at $Q_\ell \times (\eta_\ell - \eta_\gamma) \approx -0.3$

arXiv:/0803.0030 [hep-ex]



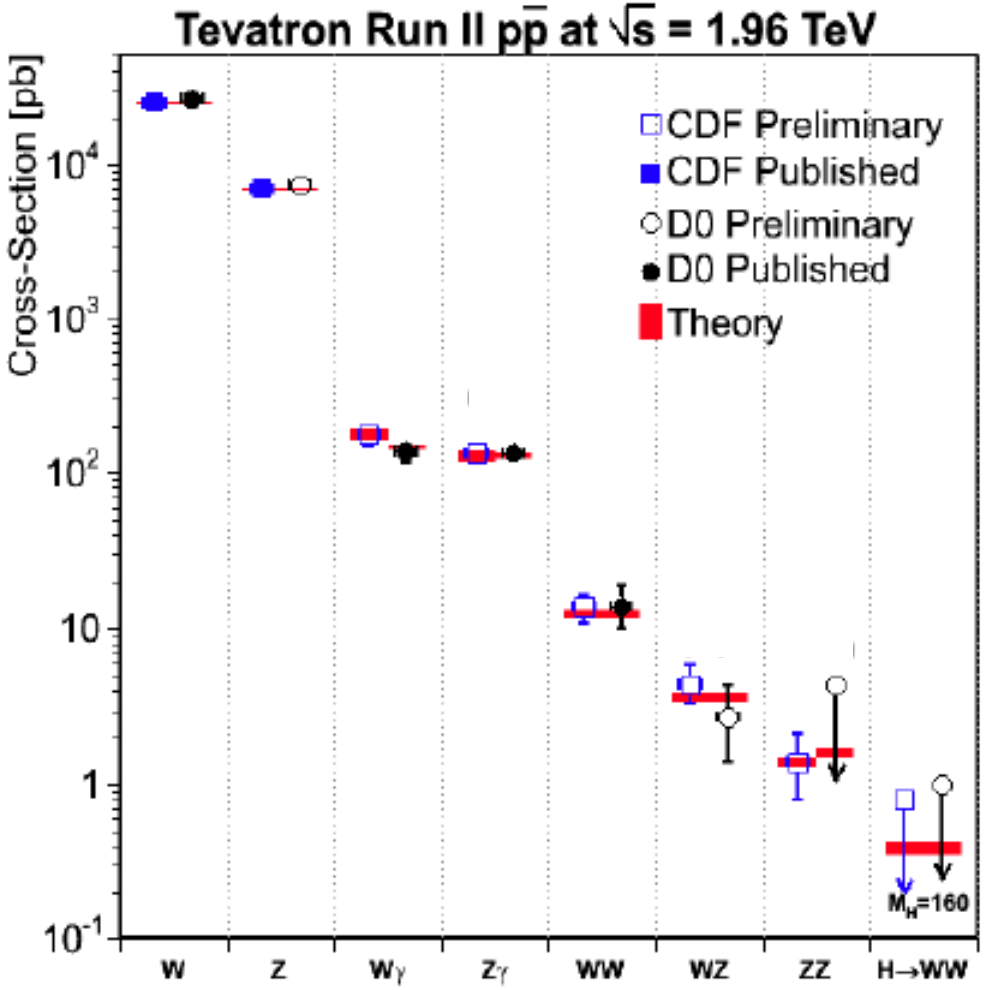
$$R = \frac{N_{\text{small max bin}}}{N_{\text{dip bin}}}$$



$$p_{\text{uni modal}} < (4.5 \pm 0.7) \times 10^{-3}$$

First indication of Radiation Amplitude Zero!

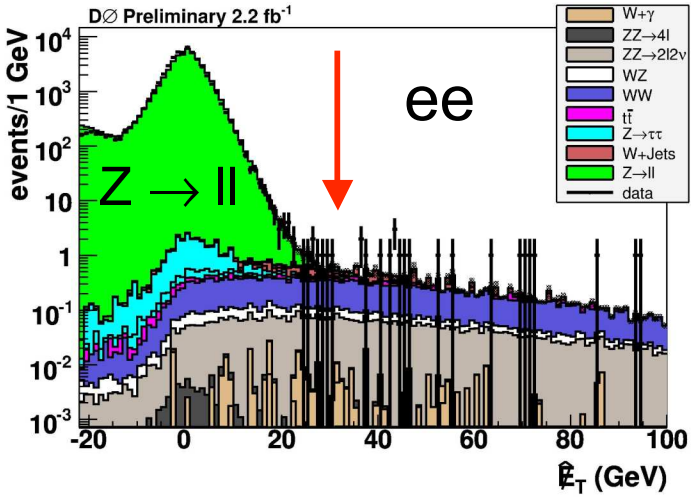
ZZ Production

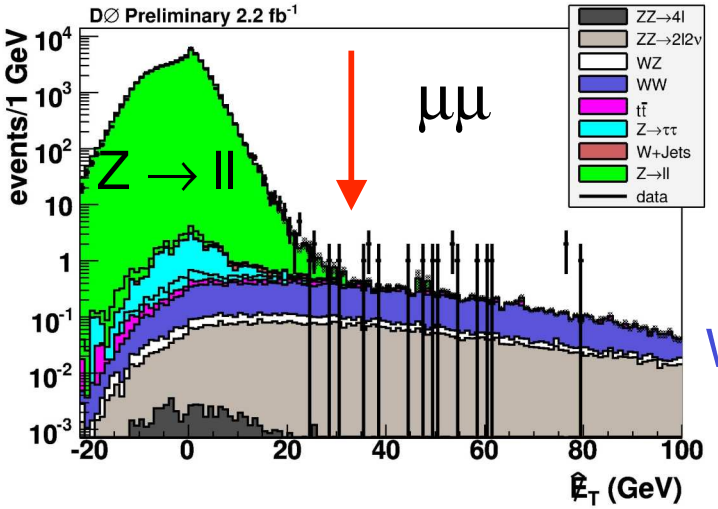


If we can observe ZZ, the SM Higgs won't be far behind

Searching in $\ell\ell\nu\nu$, $\ell\ell jj$ and 4ℓ channels

$ZZ \to \ell\ell\nu\nu$

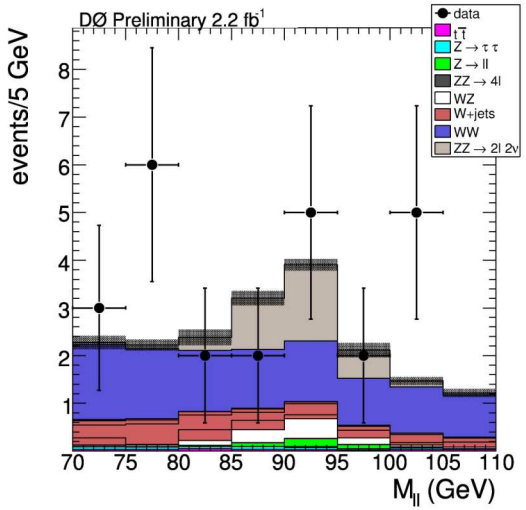




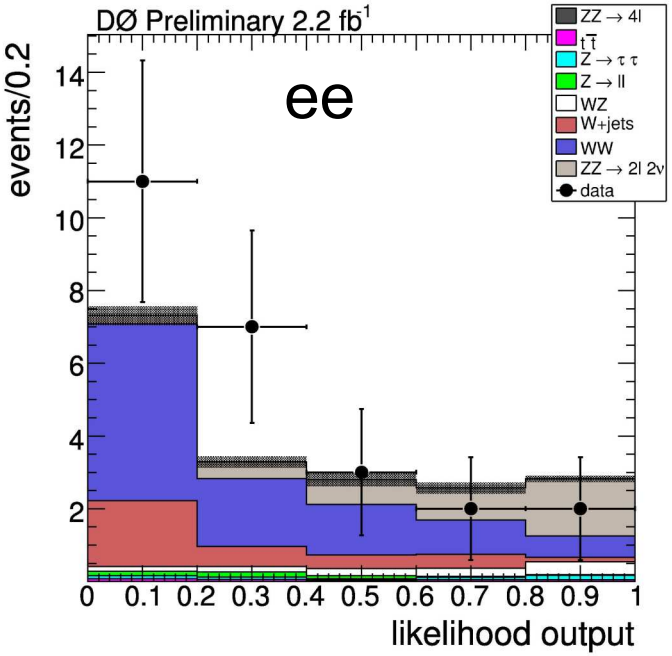
WW

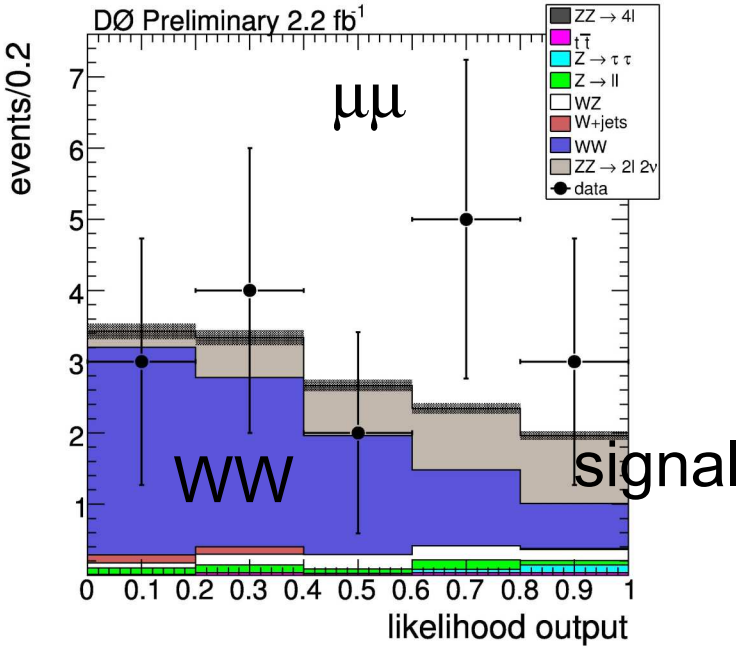
Likelihood discriminant:

- di-lepton mass
- p_T of the leading lepton
- scattering angle of the negative lepton in the di-lepton rest frame
- angle between the leading lepton and the di-lepton system



$ZZ \to \ell\ell\nu\nu$





$$\sigma(ZZ) = 2.1 \pm 1.1(stat.) \pm 0.4(syst.)\ \text{pb}$$

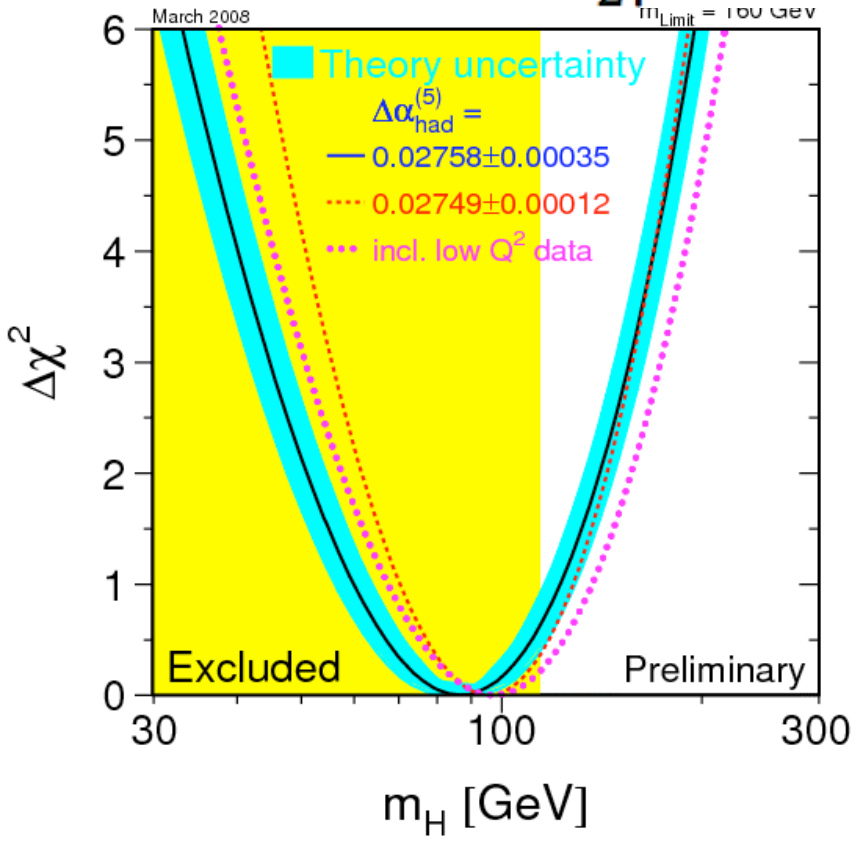
$$\sigma(ZZ) = 1.6 \pm 0.1\ \text{pb (SM)}$$

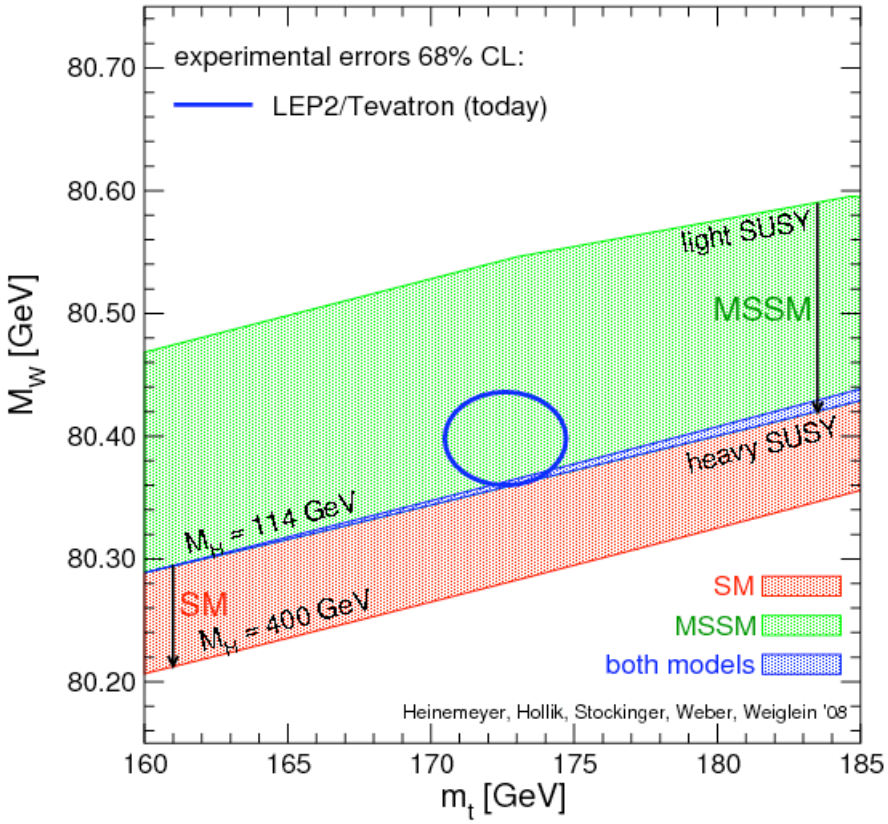
Significance: 2.4σ observed, 1.8σ expected

Searching for the SM Higgs Boson

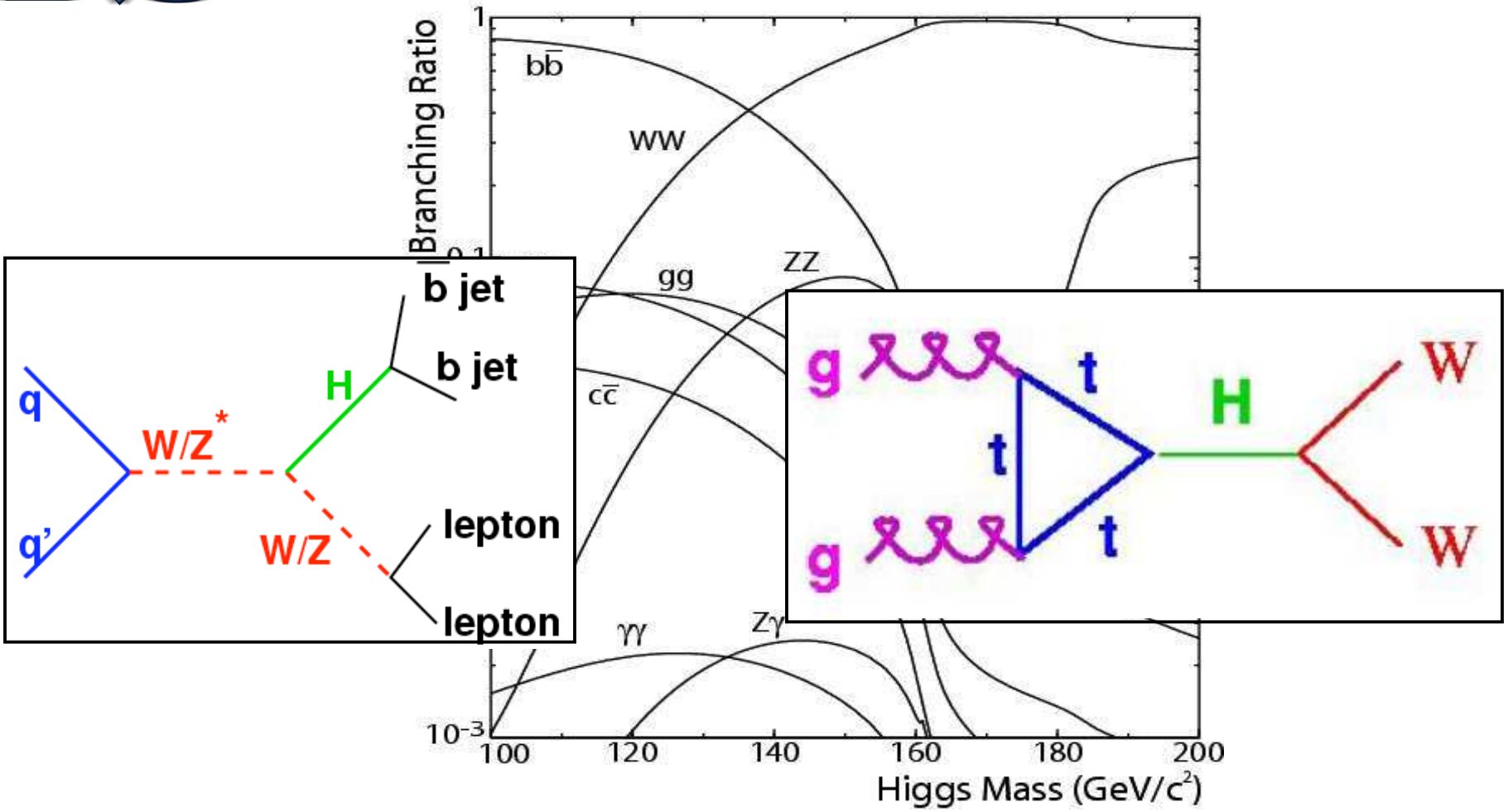
A light Higgs might be just around the corner (if the SM is correct):

$$m_H = 87 \pm {}^{36}_{27}\ \text{GeV}$$



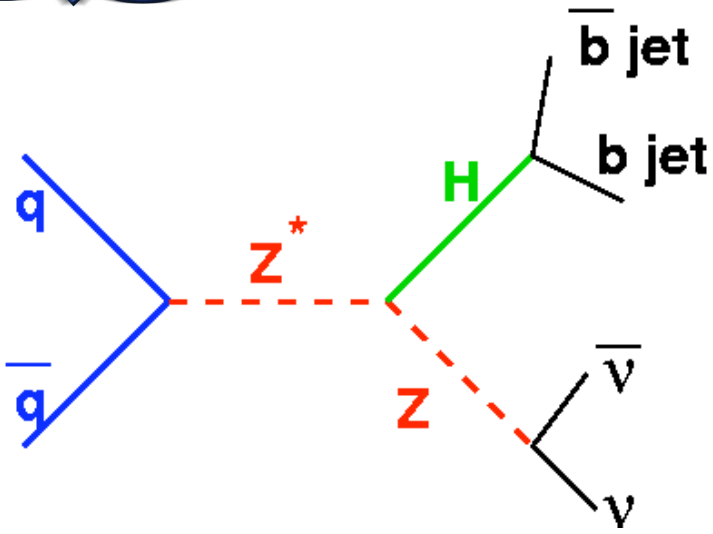


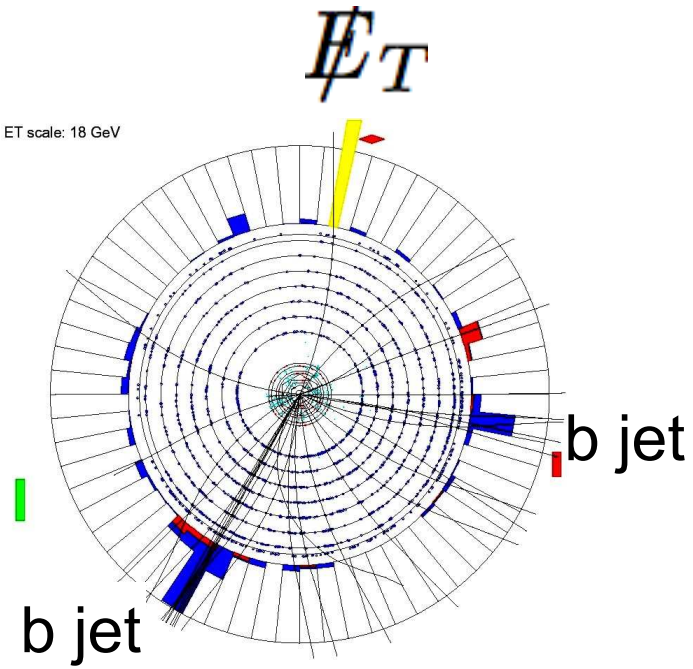
Search Strategy at the Tevatron



A combination of many production and decay modes is required

$ZH \rightarrow \nu\nu b\bar{b}$

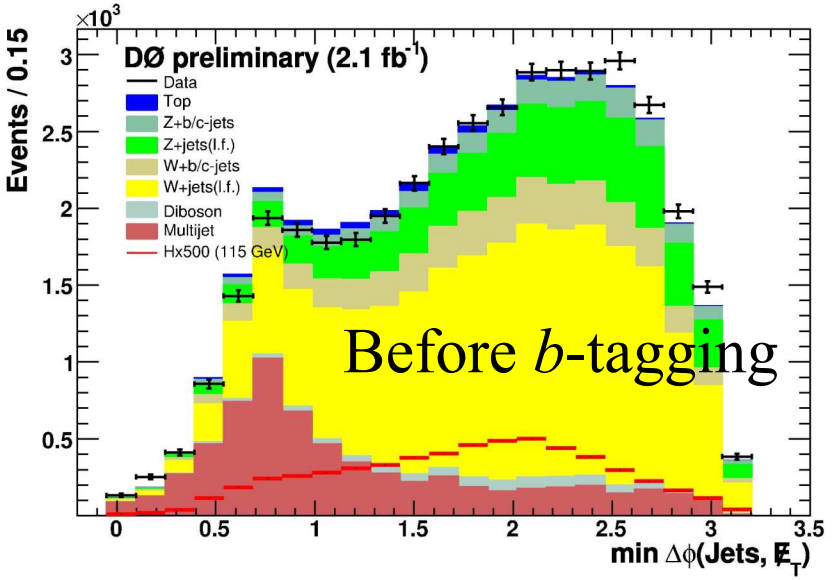




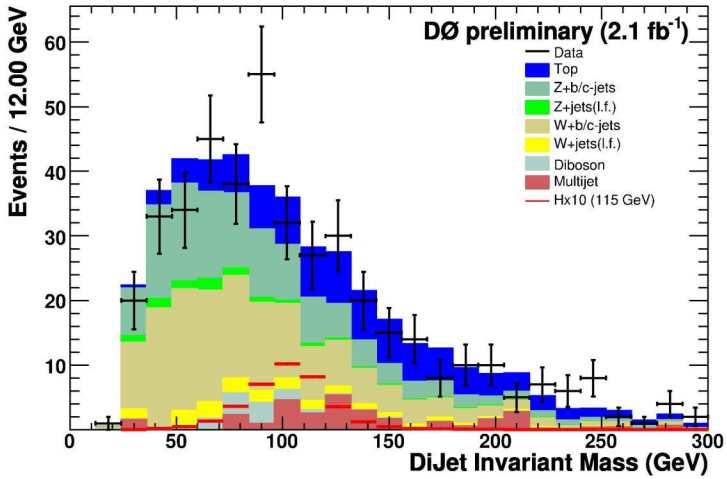
Typical selection:

two jets not back-to-back in ϕ

$\not\!\!E_T > 50$ GeV



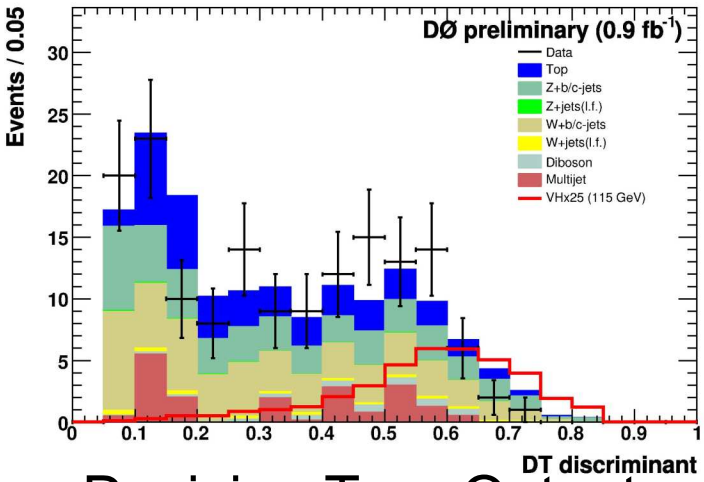
$ZH \rightarrow \nu\nu b\bar{b}$



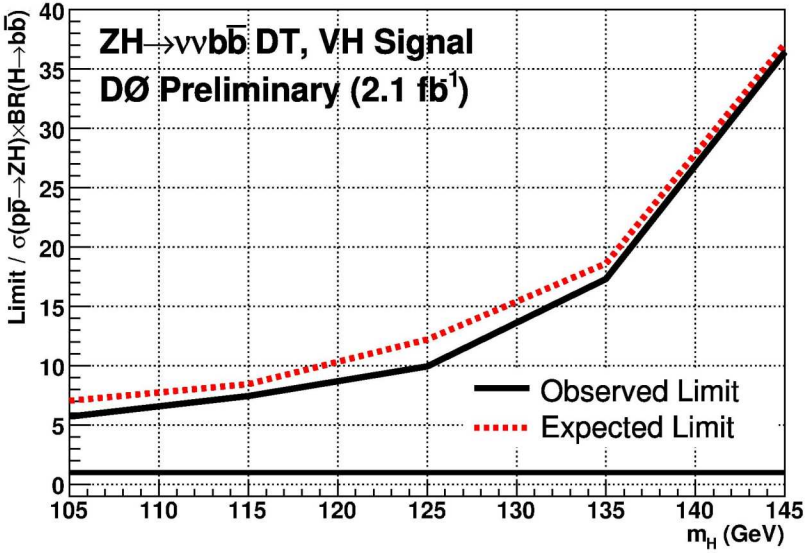
Two asymmetric b tags (one loose, one tight)

Backgrounds :

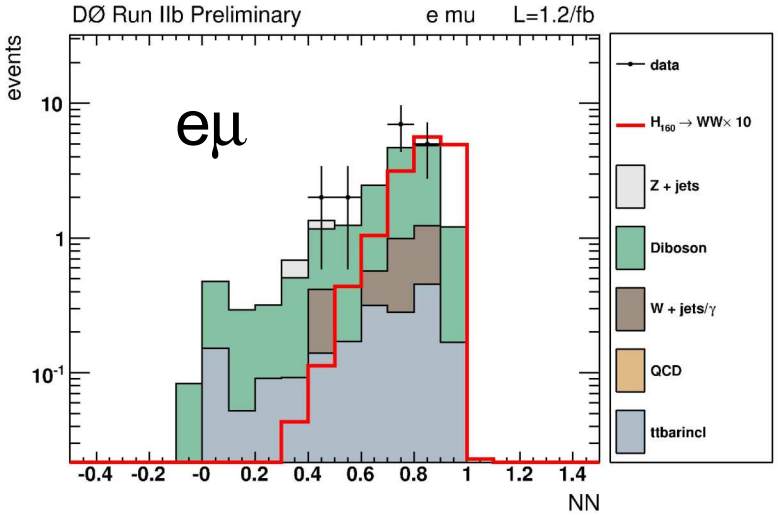
- W+heavy flavor jets
- Z +heavy flavor jets
- top pairs

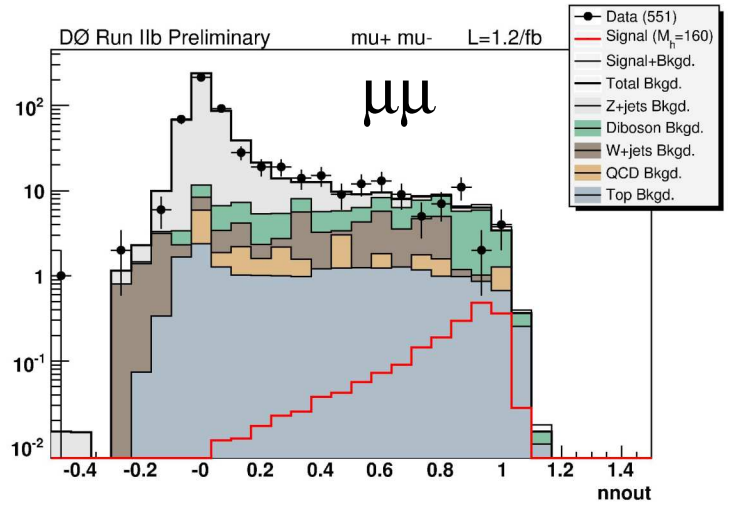


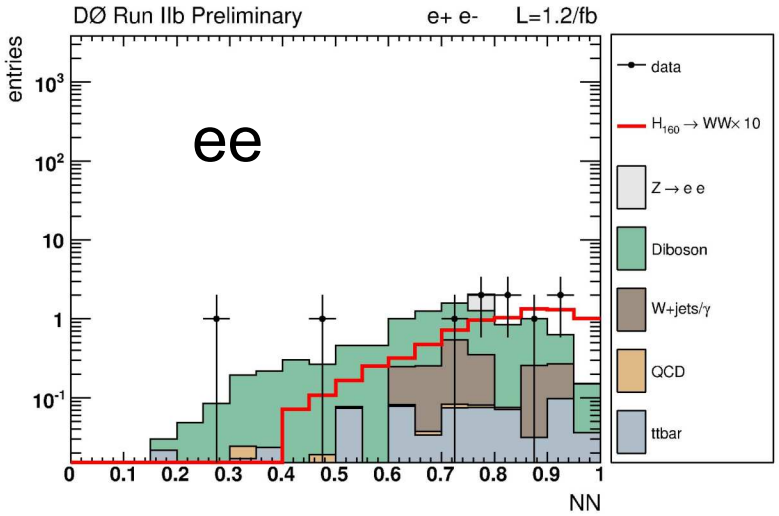
Decision Tree Output

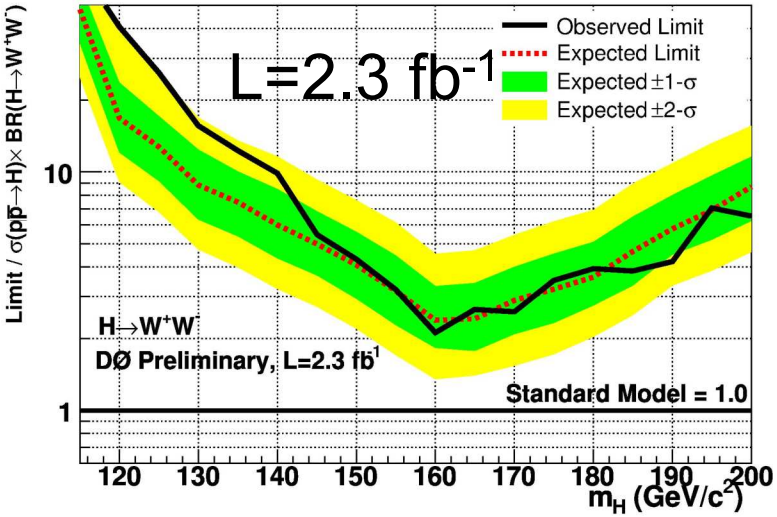


$H \rightarrow WW \rightarrow \ell\nu\ell\nu$

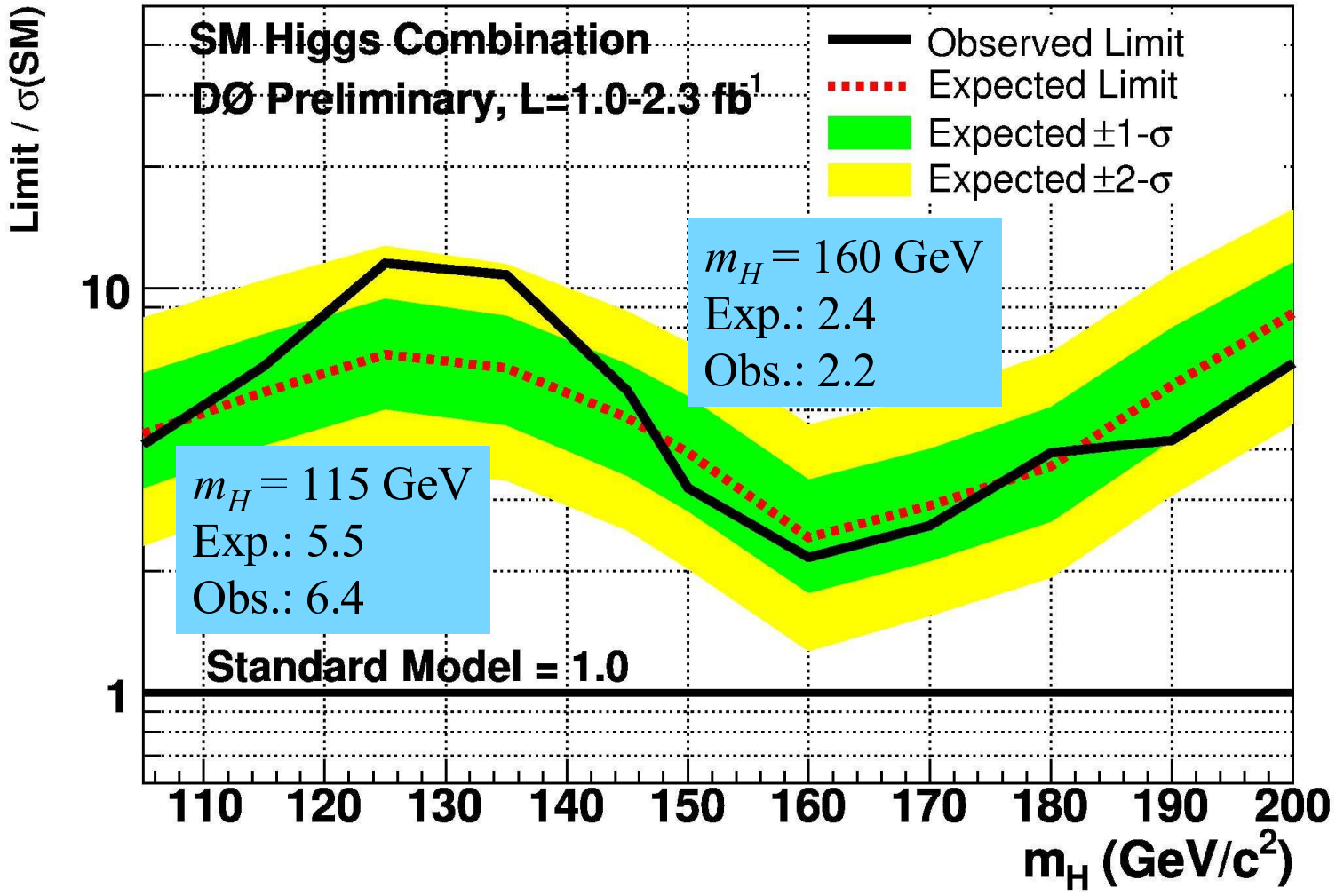




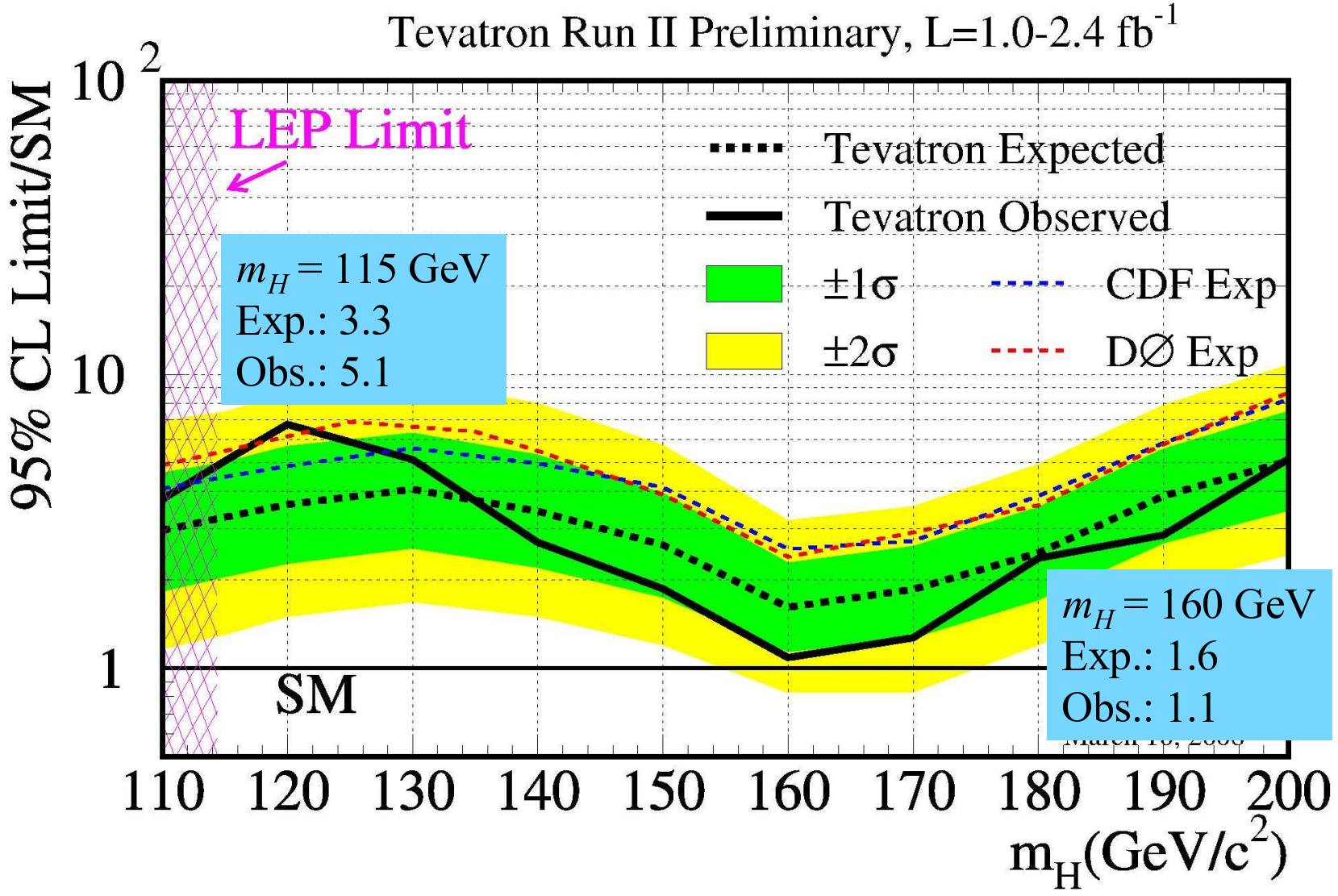




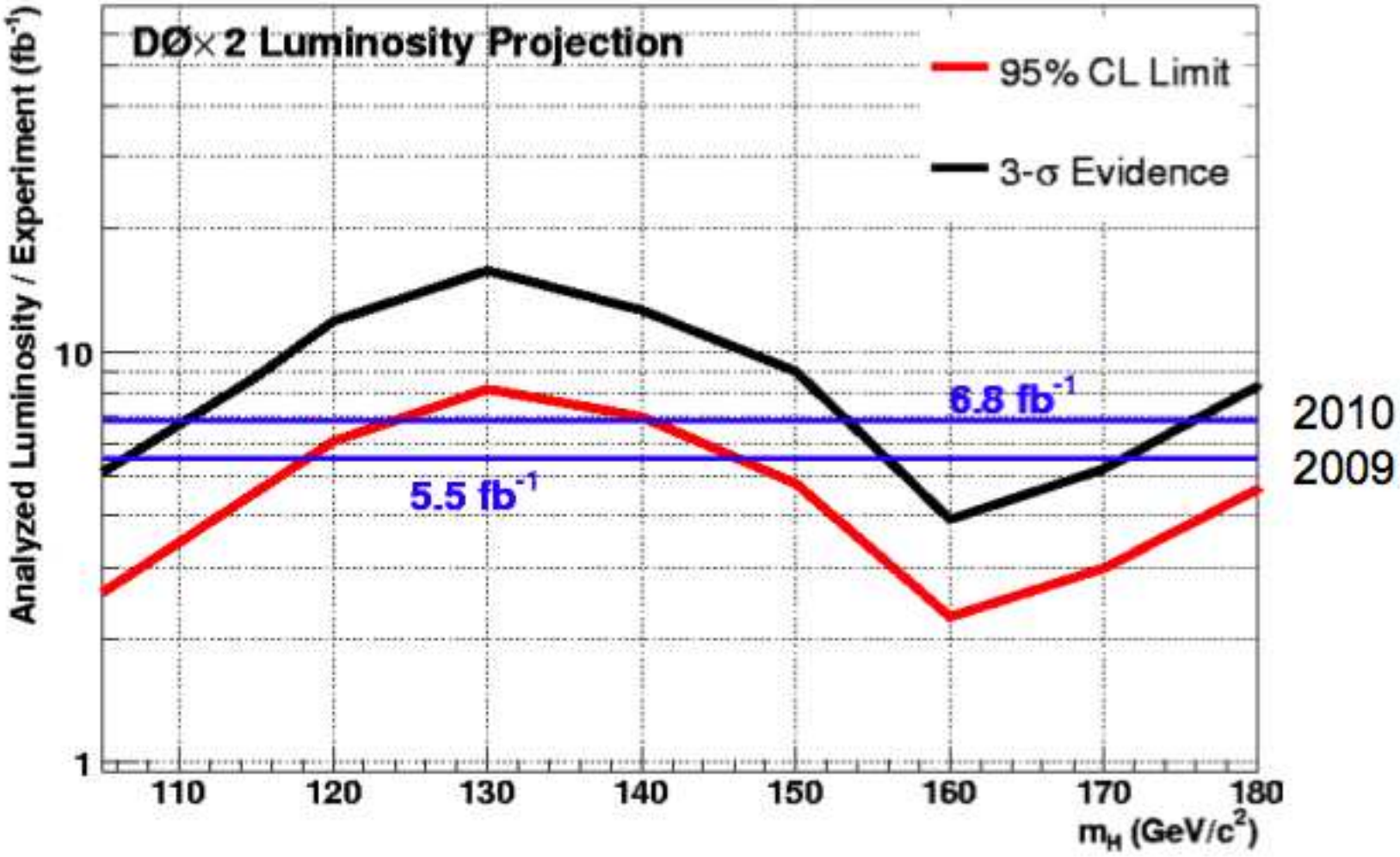
DØ March 2008 Combination



Tevatron March 2008 Combination



Higgs Limit Projections



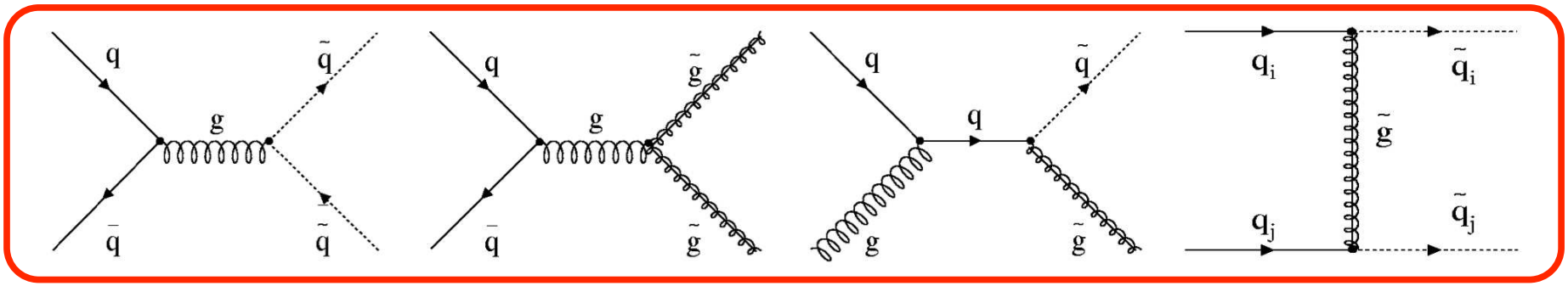
Beyond the Standard Model

If you can think of it, we can search for it!

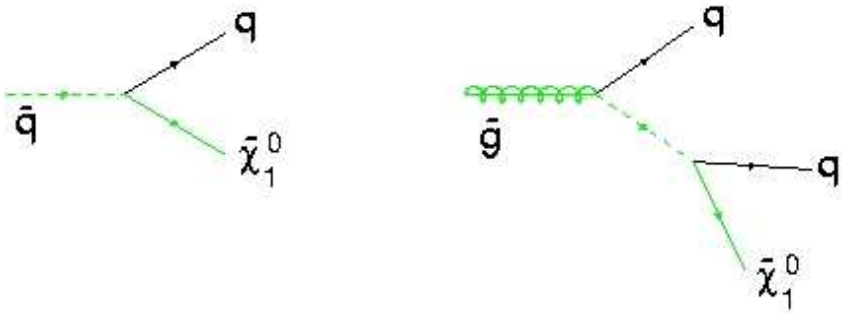
Recent studies:

-MSSM Higgs
-first, second, third generation leptoquarks
- extra gauge bosons (Z',W')
- Supersymmetry
- excited quarks and leptons (q*, e*)
- Large Extra Dimensions (LED)
- Technicolor
- charged massive stable particles
- monopoles
- …

Searches for Squarks and Gluinos



2 jets 4 jets 3 jets 2 jets



+ cascade decays

$\not\!\!E_T > 100 - 225$ GeV

$p_T^{jet} > 35$ GeV

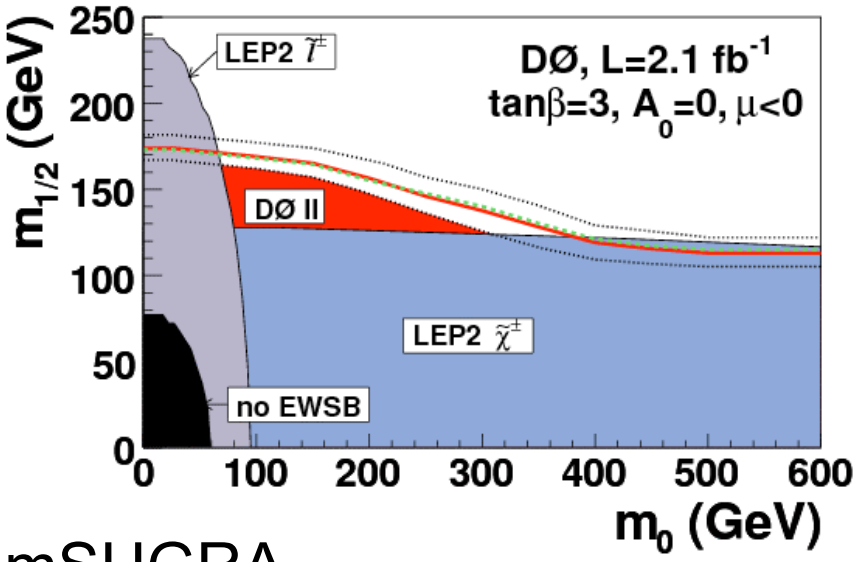
large $\Delta\phi(jets, \not\!\!E_T)$

lepton veto

Three overlapping analyses optimised for different topologies combined for final limit

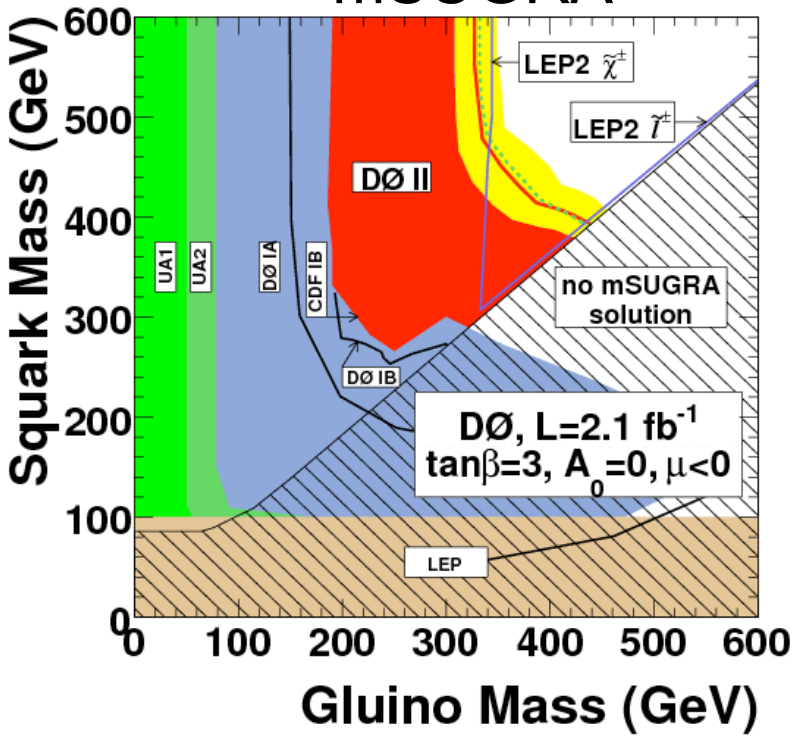
Squark and Gluino Limits

m_0: universal scalar mass
$m_{1/2}$: universal gaugino mass
A_0: trilinear coupling
all at GUT scale



mSUGRA

mSUGRA



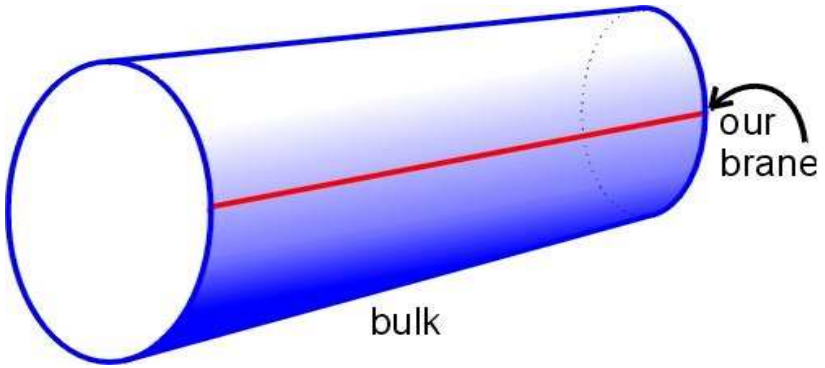
$m(\tilde{g}) > 327$ GeV

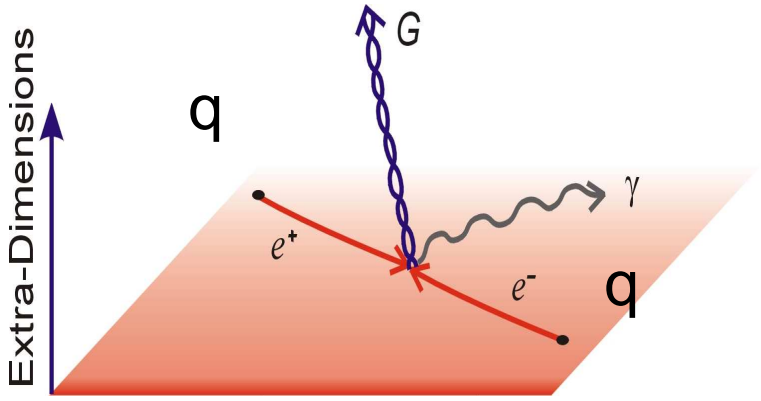
$m(\tilde{q}) > 392$ GeV

Most restrictive limits to date

Search for Large Extra Dimensions Using Mono-Photons

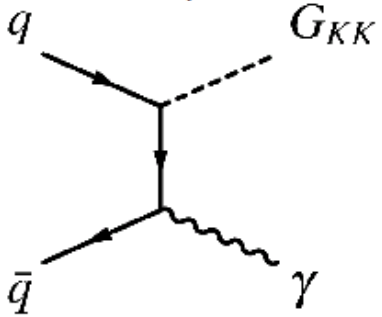
Hierarchy problem: Why is gravity so weak ?





$$M_{Pl}^2 = 8\pi M_D^{\delta+2} R^{\delta}$$

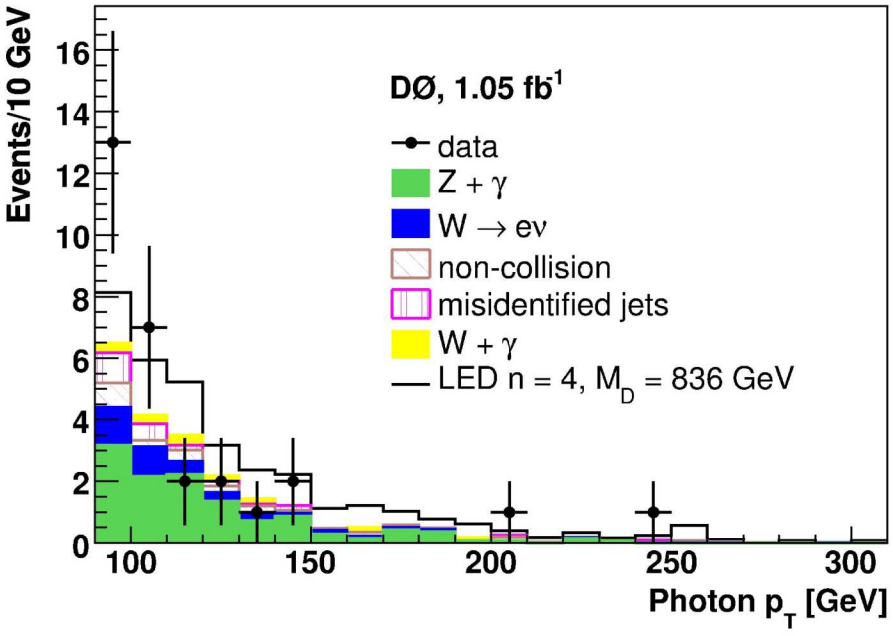
$\not{E}_T > 70$ GeV



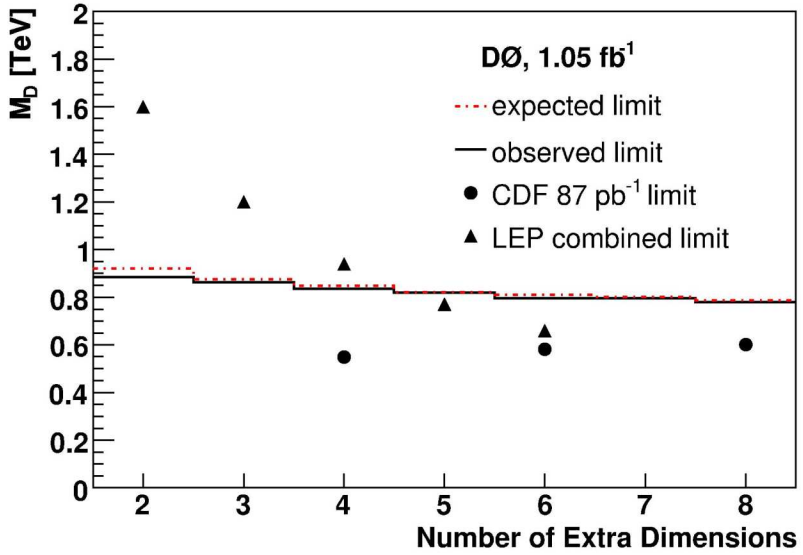
$p_T^{\gamma} > 90$ GeV

Tower of Kaluza-Klein gravitons G_{KK}
massive, non-interacting, stable

Search for Large Extra Dimensions Using Mono-Photons



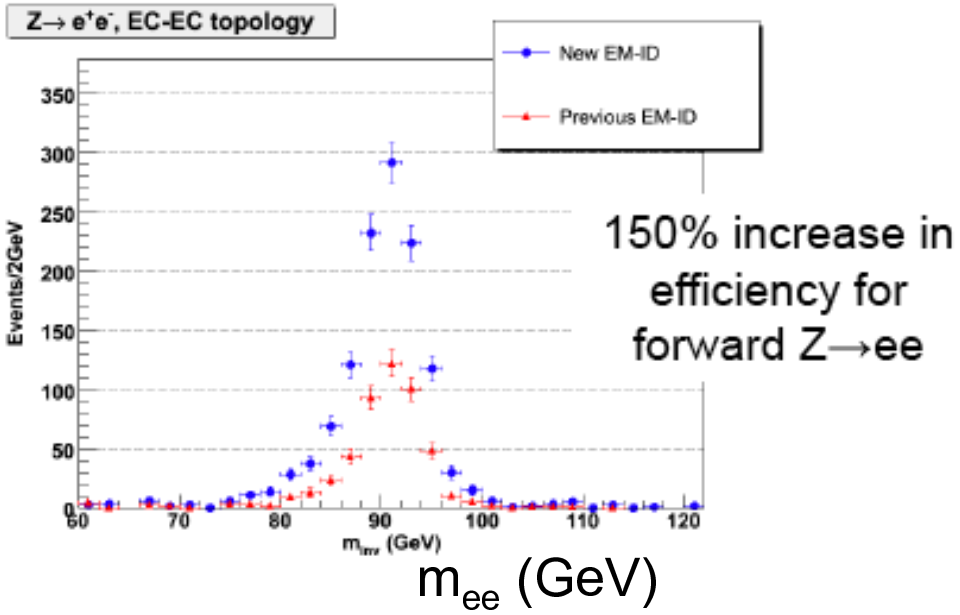
Background	Number of expected events
$Z+\gamma \to \nu\bar{\nu}\gamma$	12.1 ± 1.3
$W \to e\nu$	3.8 ± 0.3
Non-collision	2.8 ± 1.4
Misidentified jets	2.2 ± 1.5
$W+\gamma$	1.5 ± 0.2
Total Background	22.4 ± 2.5
Data	29



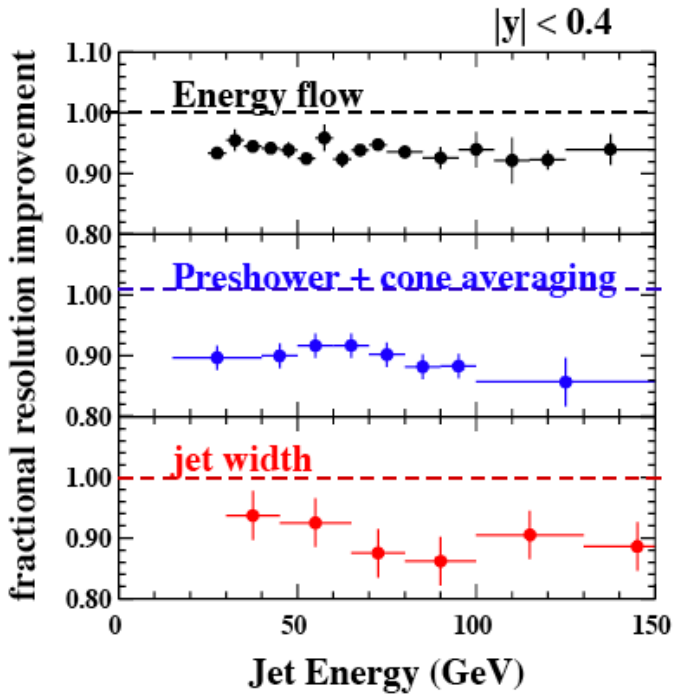
Looking to the Future

The keys to future discoveries and high precision measurements are more luminosity and continuing improvements

Electron ID



Jet energy resolution



Many new results expected for ICHEP08

Summary

- DØ operates with remarkably high efficiency
  - trigger and data reconstruction are capable of handling high-luminosity running
- Projected manpower is adequate to support running through 2010
- Presented results from a wide variety of physics analyses at recent winter conferences
  - only a small sampling possible here
  - a more complete overview can be found in last week's Wine & Cheese seminar, or on the DØ web pages
  - more than 20 papers submitted since last PAC meeting!

Most are statistics-limited

We thank the PAC for its support of running through 2010 -- and hope to reward you with more exciting results