Seminari del IFIC

Valencia, January 14, 2005

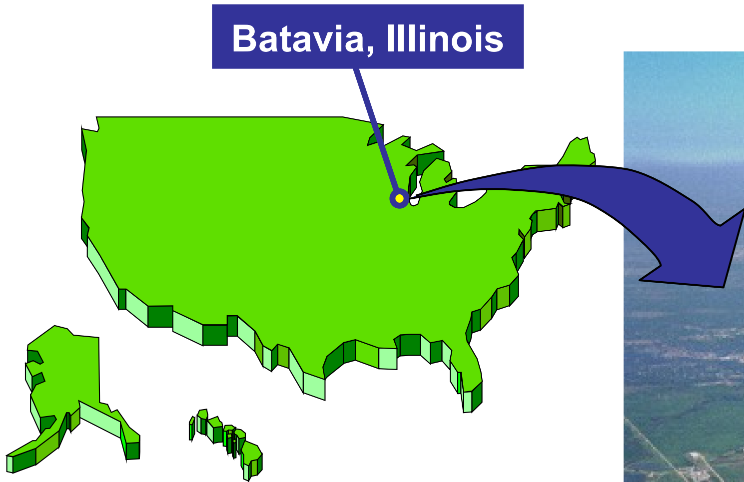
Recent results from CDF and DØ

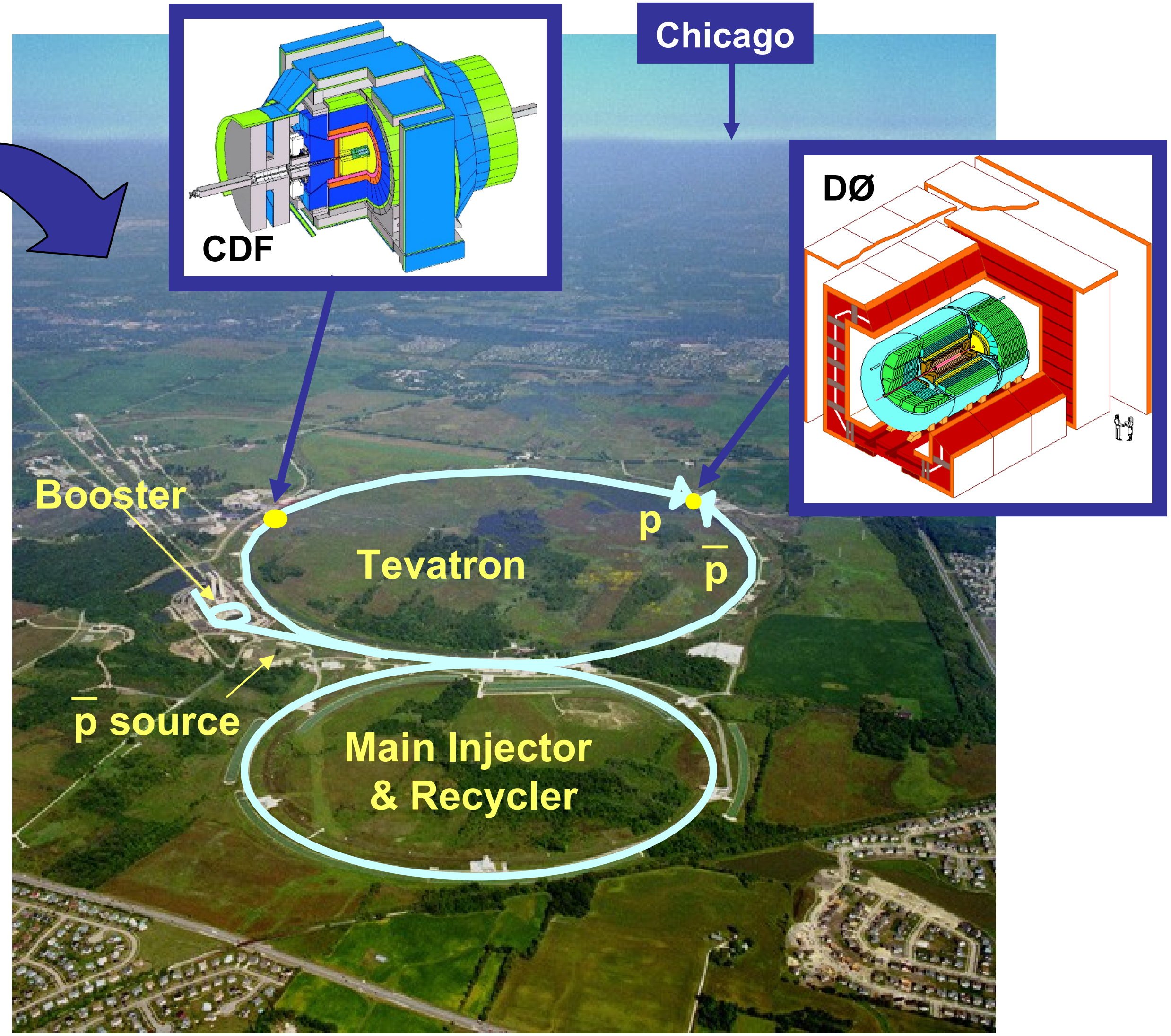
Arán García-Bellido

Outline

- Status of the Tevatron
- Run II CDF and DØ detectors
- Standard Model Physics:
  - Electroweak
  - QCD
  - B-physics
  - Top
  - Higgs
- Physics Beyond the Standard Model:
  - Searches for Supersymmetry
  - Extra dimensions
- TeV4LHC Workshop advertisement

Tevatron at Fermilab





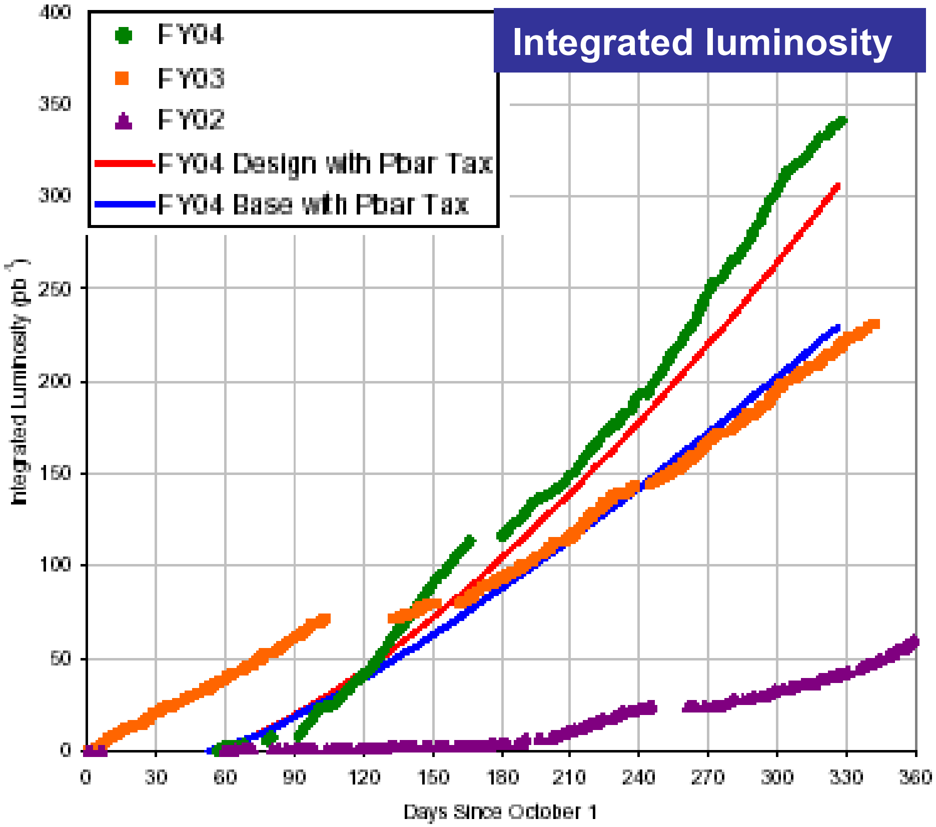
Run I 1992-95

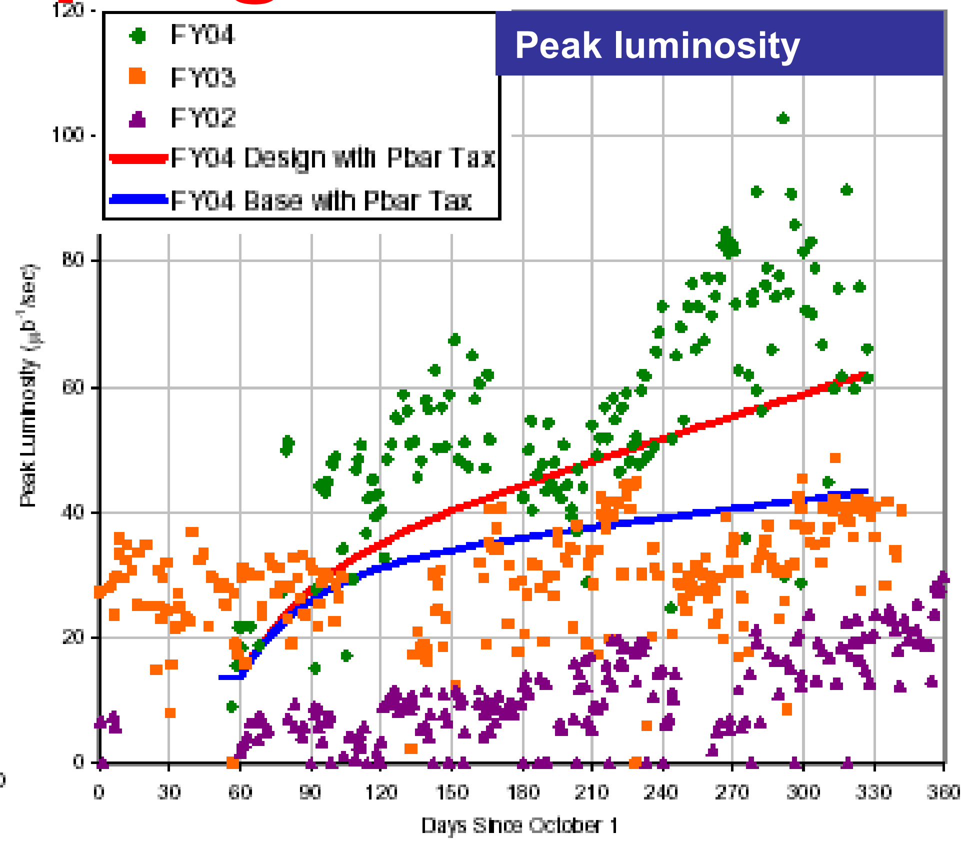
- Top quark discovered!

Run II 2001-09(?)

- $\sqrt{s}$ =1.96 TeV
- Δt = 396 ns
- 36x36 bunches
- Peak Lum 10^{32} $cm^{-2}s^{-1}$
- Delivered ~600 pb^{-1}
- (> x5 Run I)

Tevatron progress





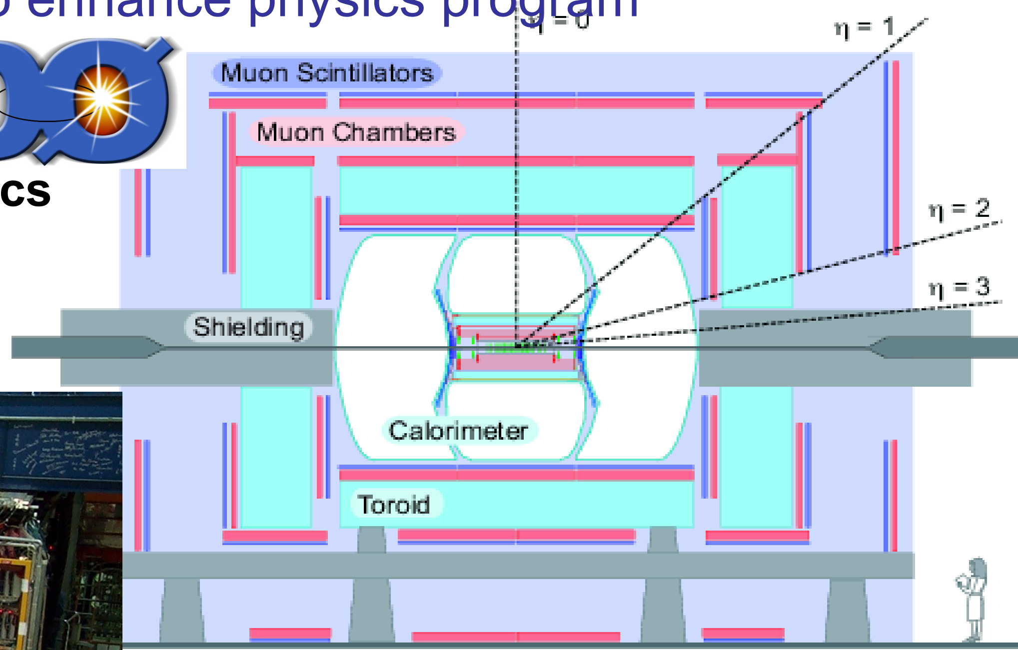
- Latest record: 1.0×10^{32} cm^{-2}s^{-1} **Great performance! Well above expectation!**
- Around 8pb^{-1}/week. Stores last around 20h
- We just had a major shutdown:
  - Electron cooling installed in the recycler
  - Still improving pbar production
  - Will aim at 14pb^{-1}/week for FY05

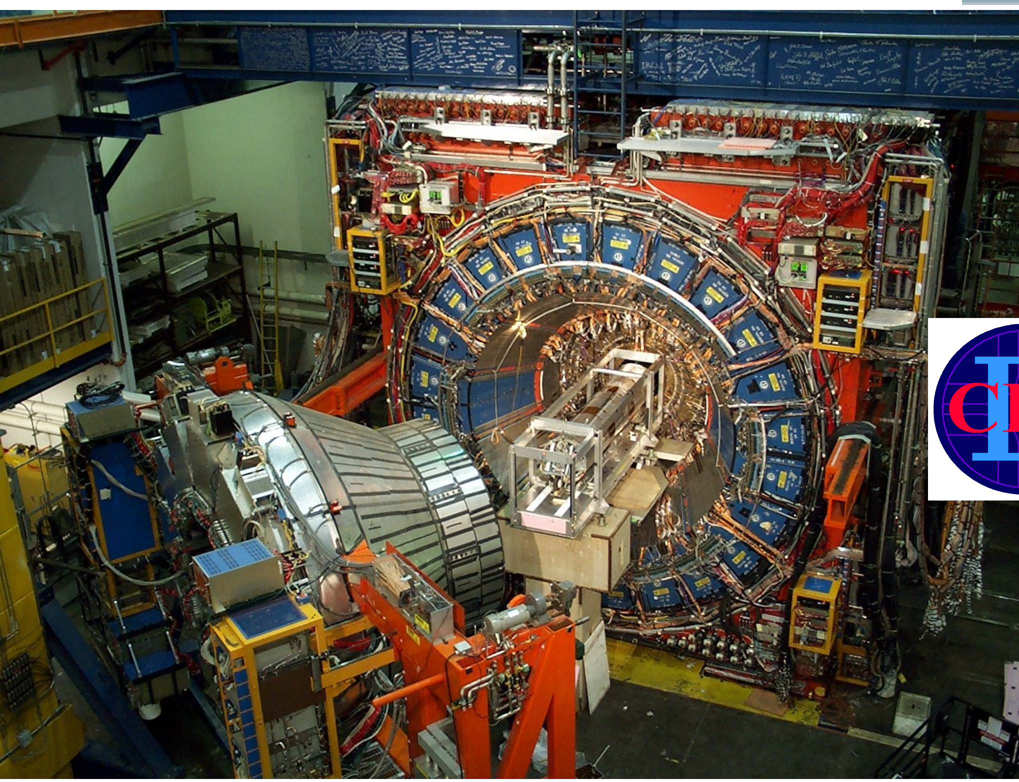
DØ was taking data after 3 minutes

CDF and DØ RunII detectors

Upgraded detectors to enhance physics program

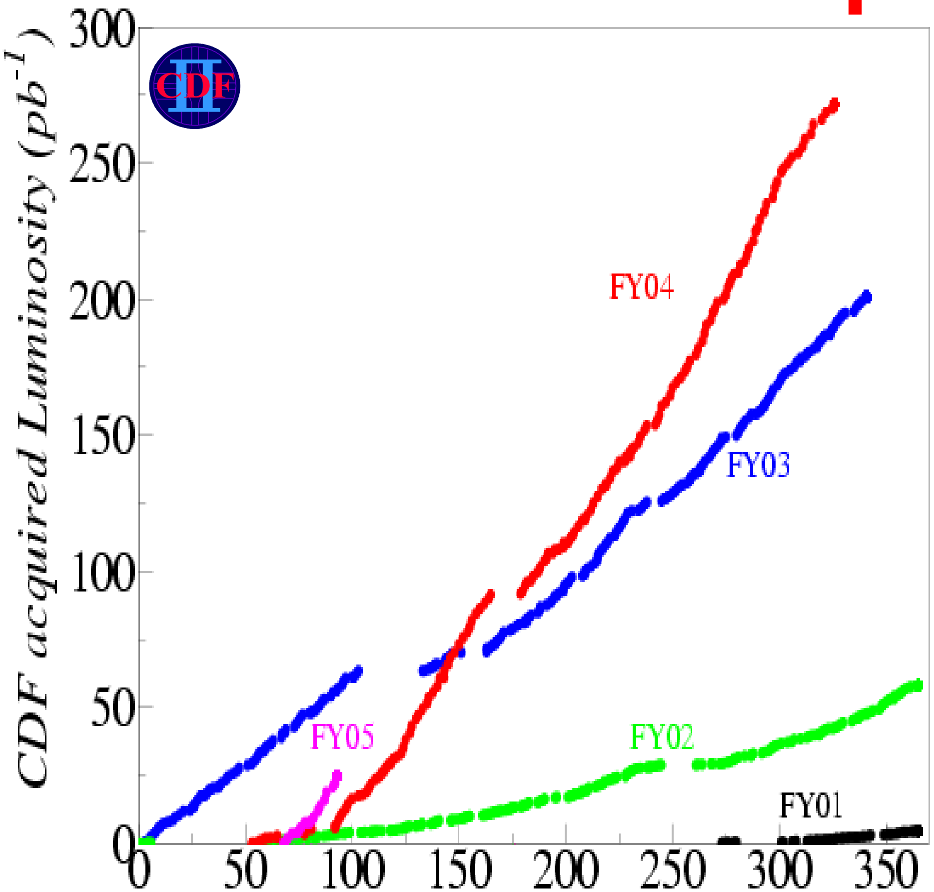
- Si + Fiber tracker + Preshowers
- 2T solenoid
- ULAr calo up to |η|=4.2 new electronics
- Muon system up to |η|=2 & shielding
- DAQ & Trigger

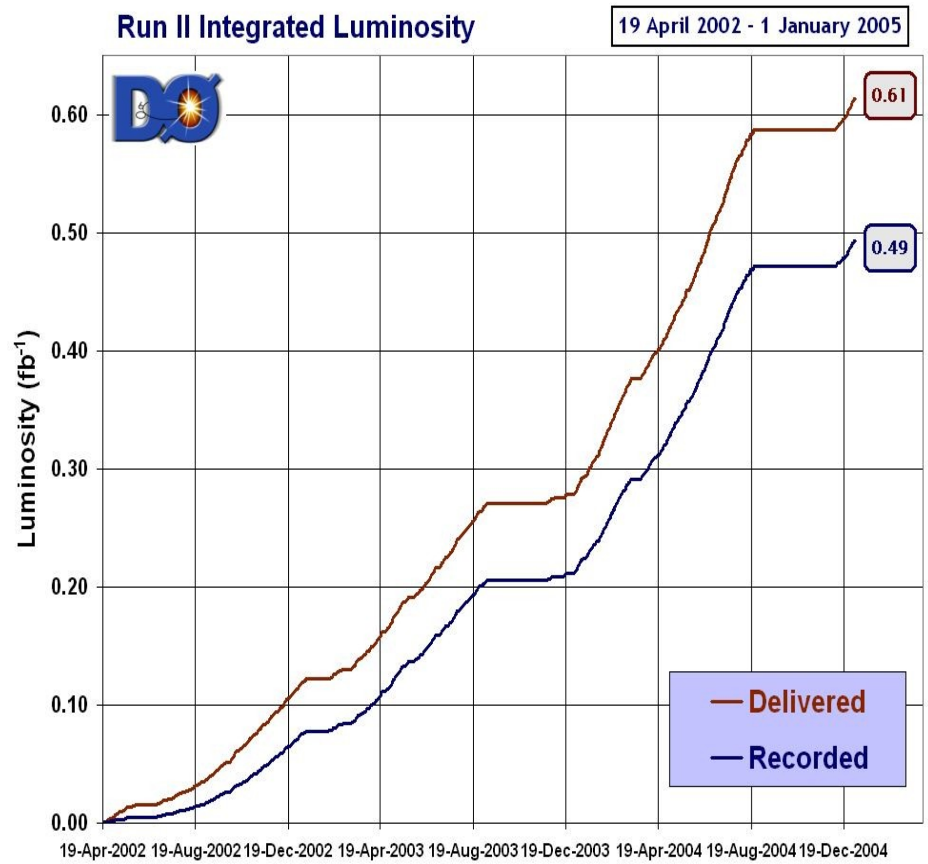




- Large Si + Time of flight detectors
- "Plug" calo up to |η|=3.6
- Forward detectors
- Muon system up to |η|=1.5 (gaps filled)
- DAQ & Trigger

Current performance

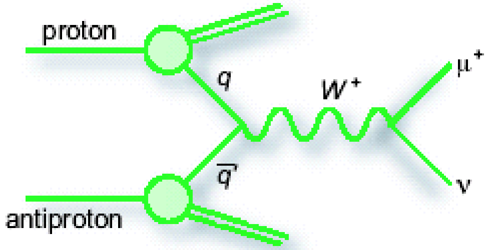


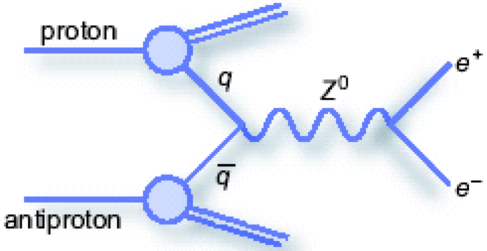


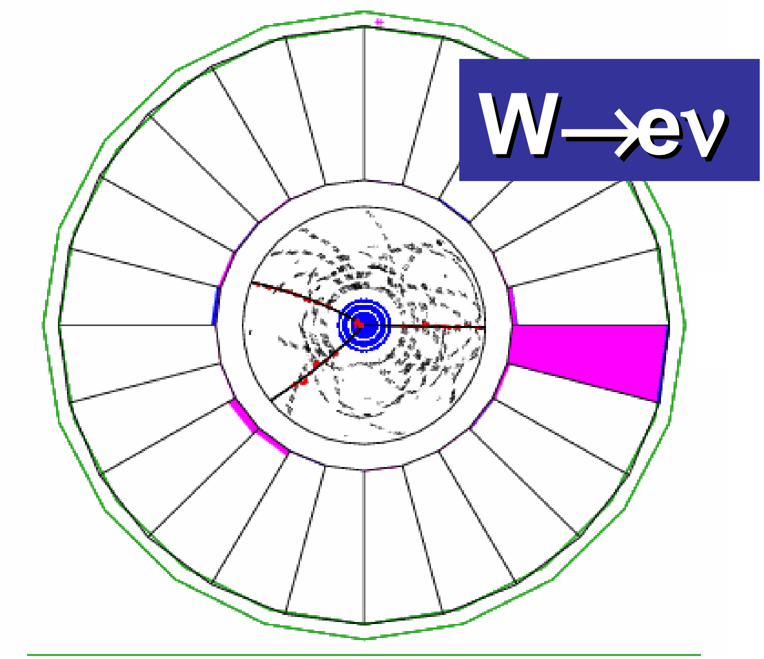
- Some 500 pb^{-1} on tape per experiment
- Data taking efficiency is usually 85-90%. Inefficiency comes from:
  - ~5% FEB, ~5% run & store transitions, ~5% “incidentals”
- Analyses shown here with 100-440 pb^{-1}

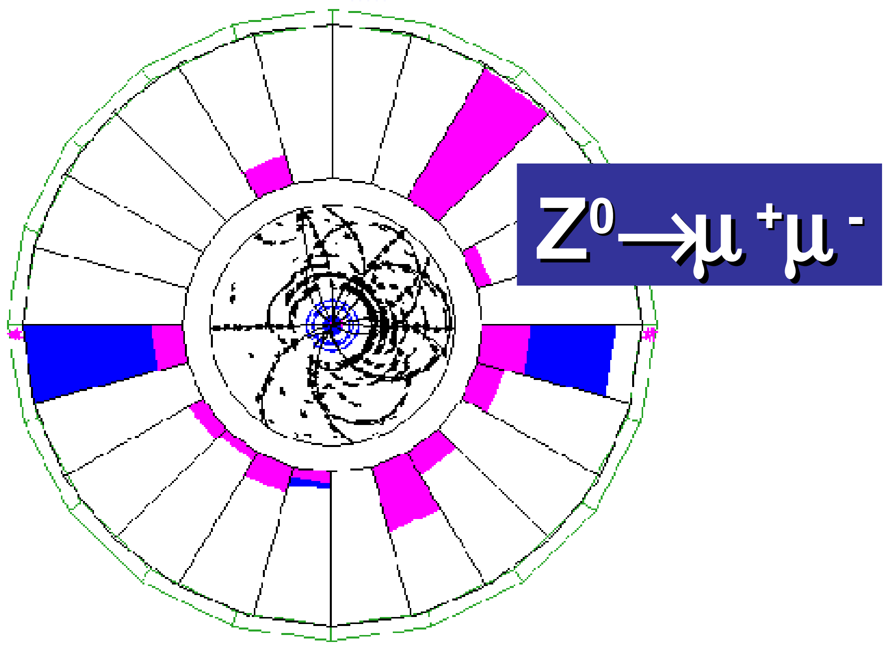
Electroweak measurements

- With 2 fb^{-1}: millions of $W \rightarrow \ell\nu$ events and 100k $Z \rightarrow \ell\,\ell$ events:
  W/Z cross sections, mass, width, asymmetries, TGC's, ℓ universality,…
- Benchmark studies to understand the detectors
- Important backgrounds to top and Higgs physics





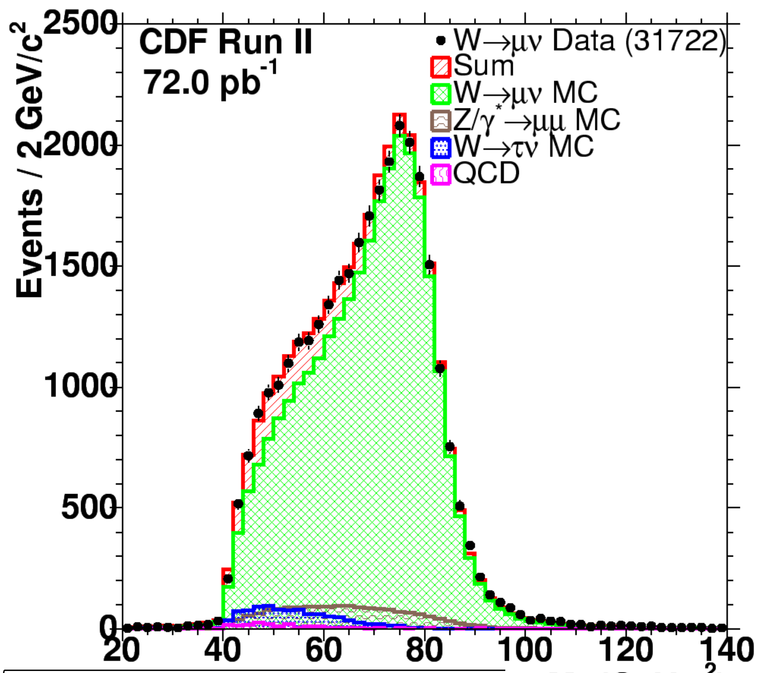




$$\sigma \cdot \mathrm{BR} = \frac{N_{obs} - N_{bkg}}{A\varepsilon \int L dt}$$

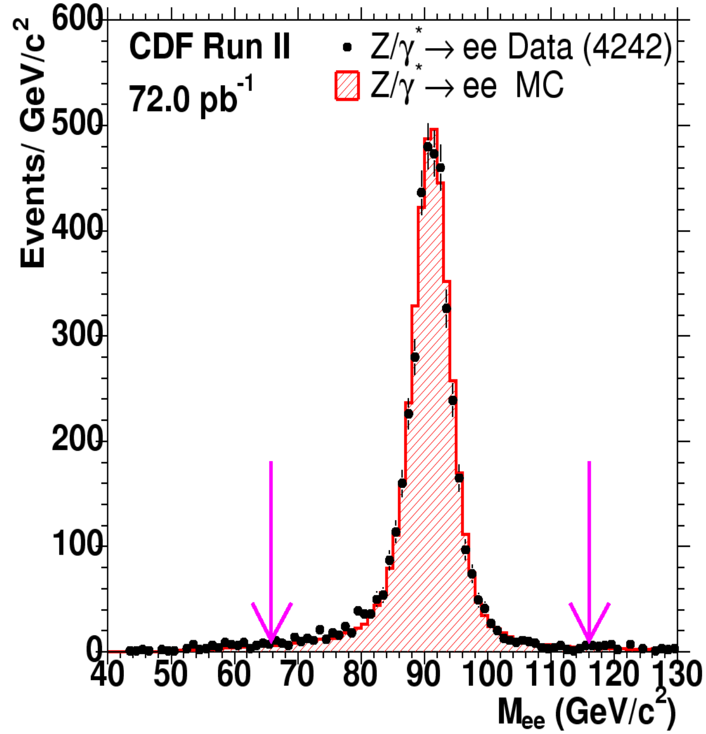
W and Z cross sections

hep-ex/0406078



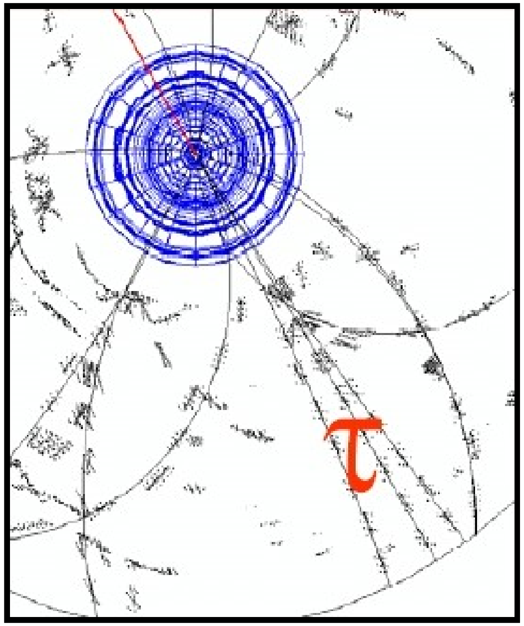
$$M_T = \sqrt{E_T(\ell)\cdot E_T(\nu) - p_x(\ell)\cdot p_x(\nu) - p_y(\ell)\cdot p_y(\nu)}$$

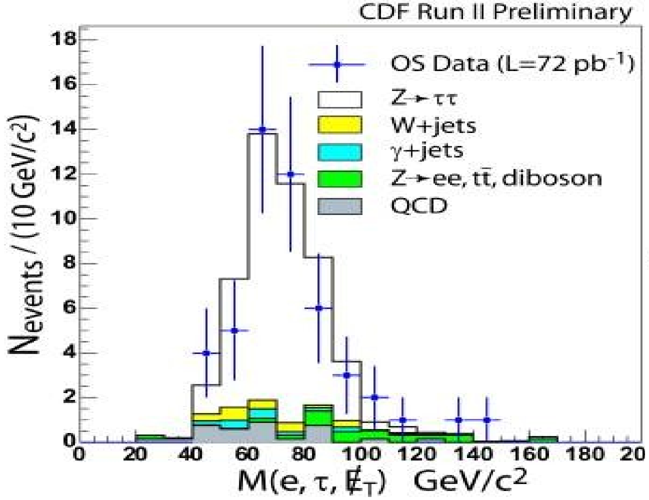
M_T (GeV/c^2)

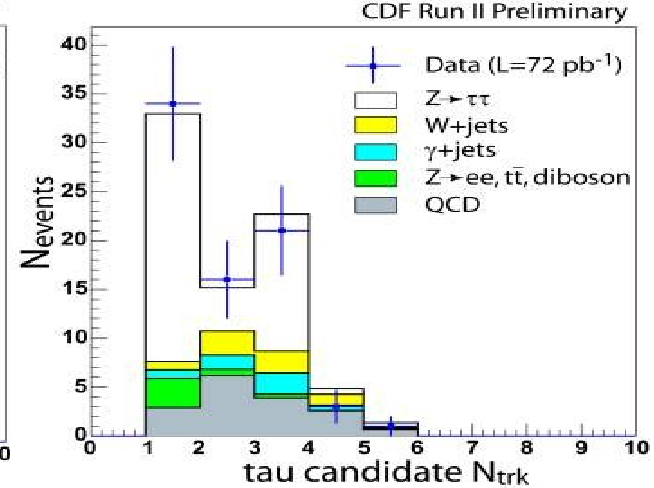


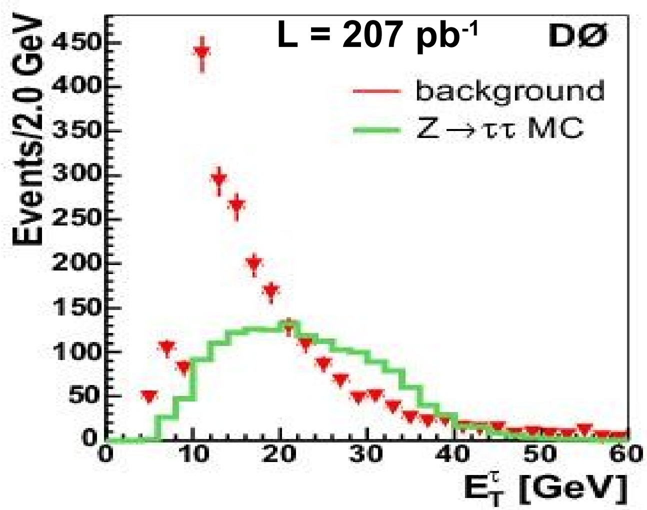
channel	$W \to e\nu$	$W \to \mu\nu$	$Z \to e^+e^-$	$Z \to \mu^+\mu^-$
Precision	**2.2%**	**2.4%**	**2.6%**	**3.9%**
category				
N candidates	37584	31722	4242	1785
acceptance	0.2397 ± 0.0036	0.1970 ± 0.0025	0.3182 ± 0.0040	0.1392 ± 0.0027
efficiency	0.749 ± 0.009	0.732 ± 0.013	0.713 ± 0.012	0.713 ± 0.015
background	1656 ± 300	2990 ± 140	62 ± 18	13 ± 13
cross section (pb)	$2780 \pm 14 \pm 60$	$2768 \pm 16 \pm 64$	$255.8 \pm 3.9 \pm 5.5$	$248.0 \pm 5.9 \pm 7.6$

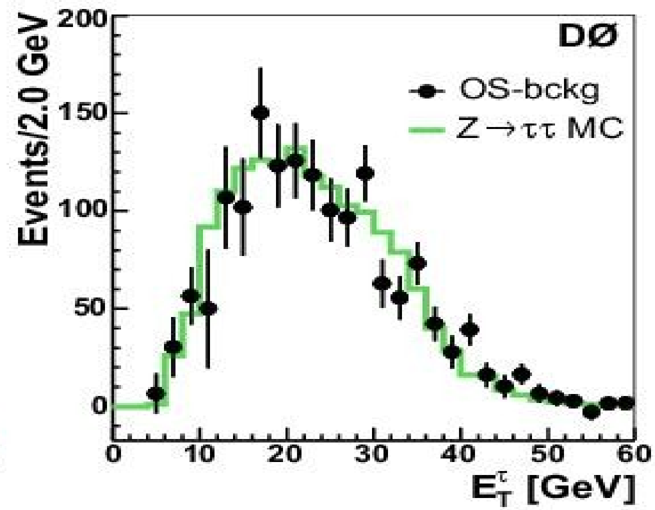
First hadron collider result on $Z\rightarrow\tau\tau$







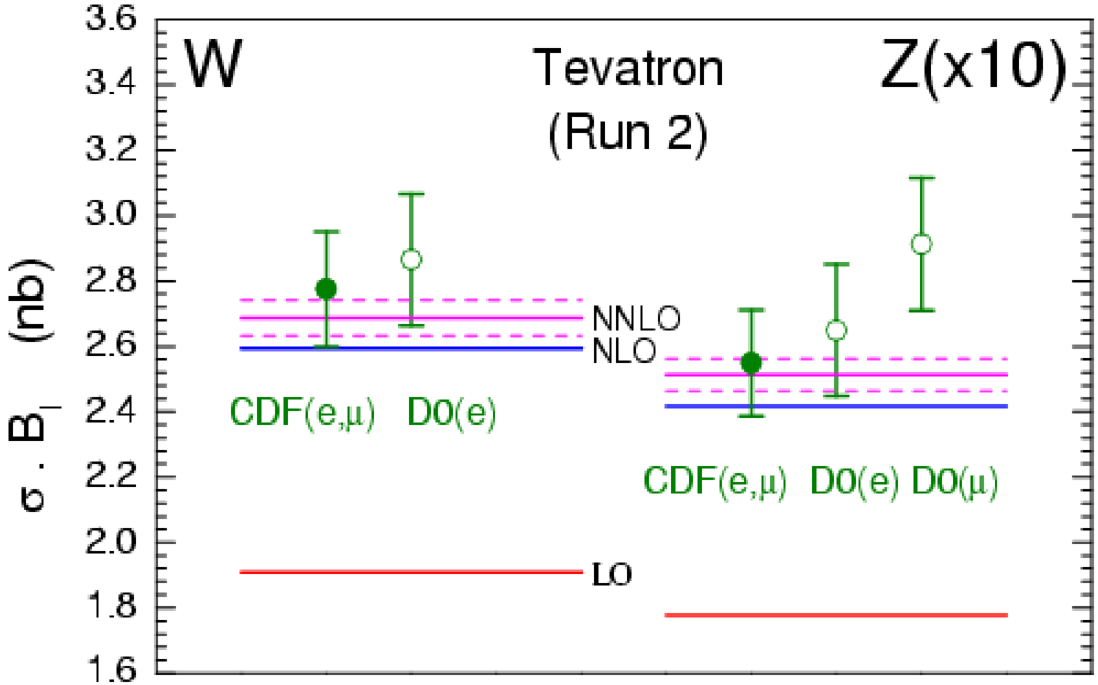




hep-ex/0412020

$$\sigma \cdot \mathrm{BR}(Z \rightarrow \tau\tau) = 237 \pm 15(stat) \pm 18(syst) \pm 15(lum)\,\mathrm{pb}$$

W/Z σ compared to theory

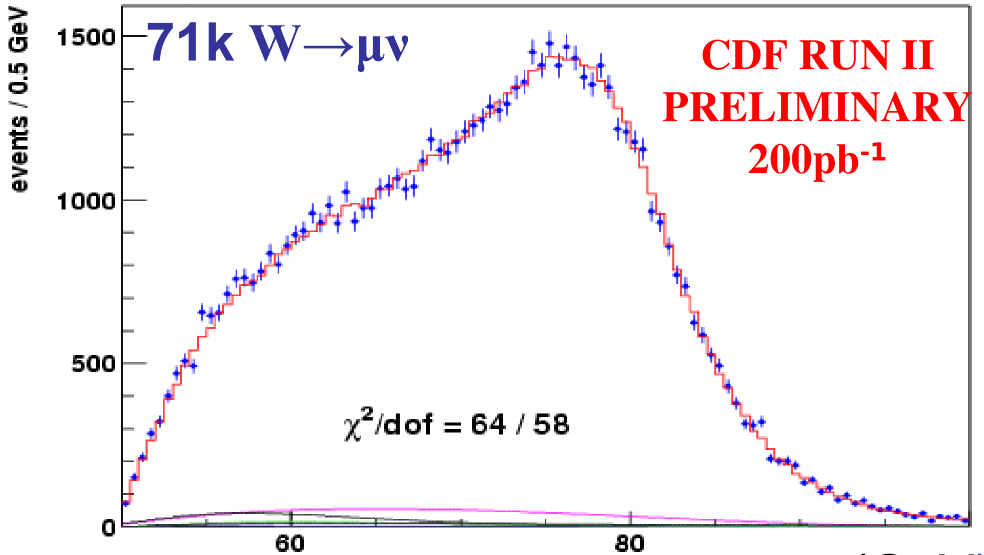


NNLO, Van Neerven et al. (Nucl. Phys. B359, 343, 1991)

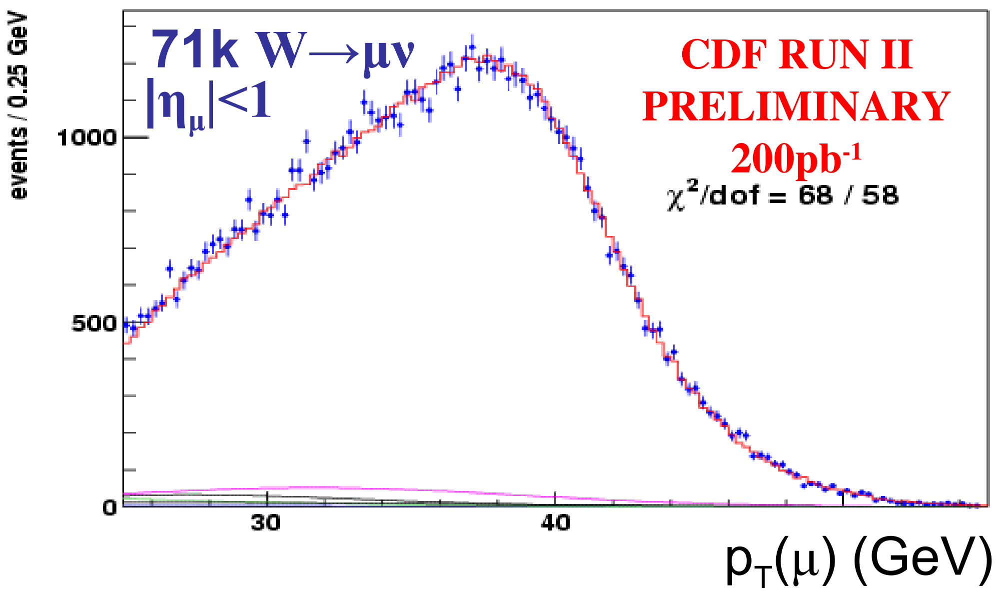
Results compatible with SM
Many other results:
- ▶ **Diboson (WW, WZ, Wγ , Z γ) σ**
  No deviations (…yet!)
- ▶ **W+jets, Z+jets, Wb, Zb**
- ▶ **σ(Z+b)/σ(Z+jets)**
  sensitive to b PDF
- ▶ **Γ(W) improves world average**
- ▶ **Forward-backward asymmetry**
- ▶ **W mass is a more complicated beast (see next)**

Tevatron EW Working Group:
http://tevewwg.fnal.gov

W mass prospects



$$M_T = \sqrt{2E_T^{\ell}E_T^{\nu}(1-\cos\phi_{\ell\nu})} \text{ (GeV)}$$



Measure W mass from fit to:

1. W transverse mass
   - ► Hadronic recoil model
   - ► Dominated by resolution
   - ► Best statistical power
2. Muon p_T or electron ET
   - ► W p_T model
   - ► Dominated by QCD model
   - ► Use high statistics samples to calibrate ℓ momentum

- ►Statistical error 50 MeV/channel
- ►Dominant systematic uncertainty from lepton energy/momentum resolution
- ►Lot of effort on detector calibration
- ►Very difficult and demanding

W mass prospects

First experience with 200 pb^{-1} of Run II data from CDF:

Systematic	Electrons (Run 1)	Muons (Run 1)
Lepton Energy Scale and Resolution	70 (80)	30 (87)
Recoil Scale and Resolution	50 (37)	50 (35)
Backgrounds	20 (5)	20 (25)
Statistics	45 (65)	50 (100)
Production and Decay Model	30 (30)	30 (30)
Total	105 (110)	85 (140)

Combined uncertainty: 76 MeV, already better than Run I from:
CDF (79 MeV) or DØ (86 MeV)
Could approach ~50 MeV by summer 2005 (~ 360pb^{-1})
Would become the single best measurement (ALEPH 58 MeV)

In order to feed Run II data into PDF's and production models for phenomenologists, thinking of providing the "raw" data in pT and y bins corrected for backgrounds but not for acceptance and provide a fast MC that simulates DØ given a 4-vector

QCD and Jet physics

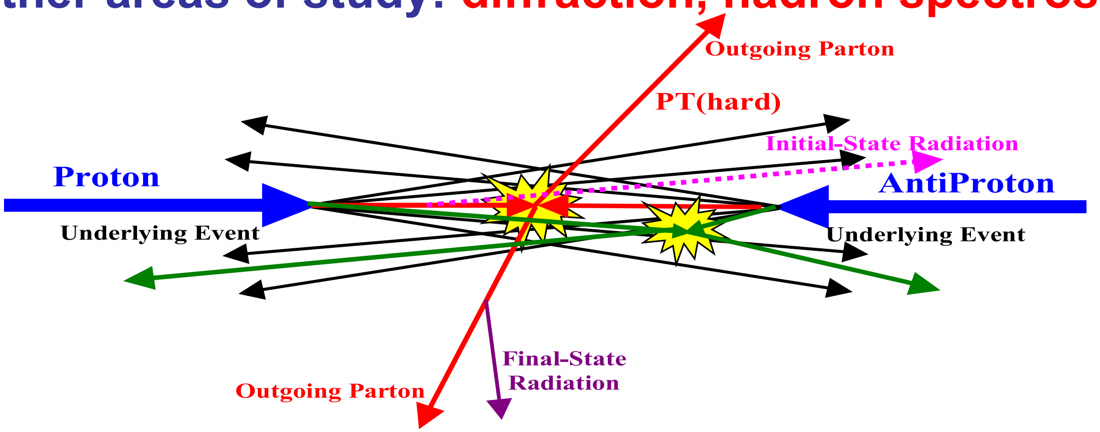
- The Tevatron is the highest energy jet-factory: everything is QCD related
- Highest Q^2 probed ~10^{-17}cm → precise test of perturbative QCD at NLO:

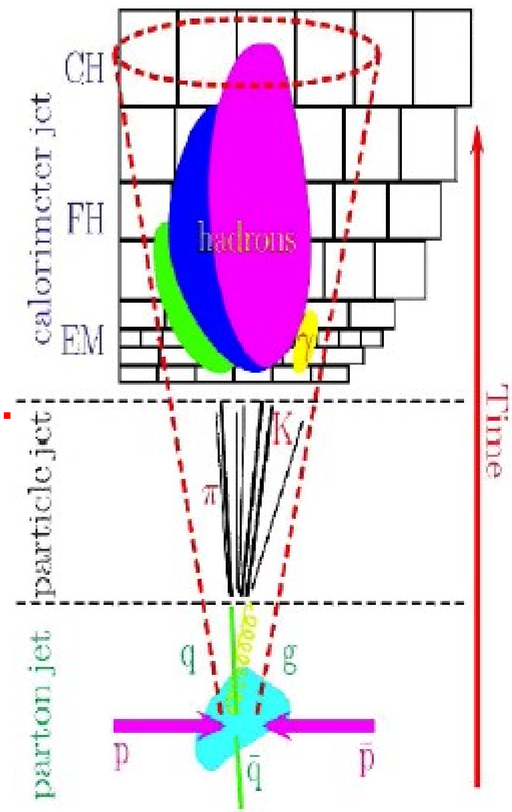
  jet and dijet cross sections, PDFs at high x, W/Z+jets, diphotons,

  jet evolution, heavy flavor quark production, azimuthal decorrelation,...
- Look for deviations and new physics

  quark compositeness, α_s ,…
- Study of phenomenology on non-perturbative regime:

  underlying event modeling
- Other areas of study: diffraction, hadron spectroscopy,…



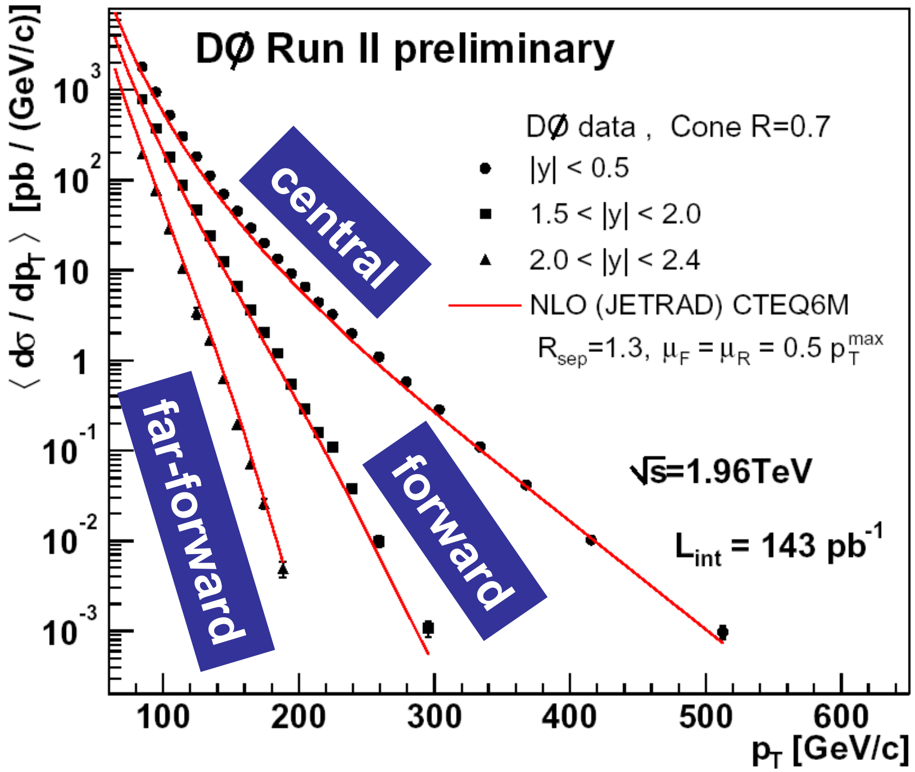


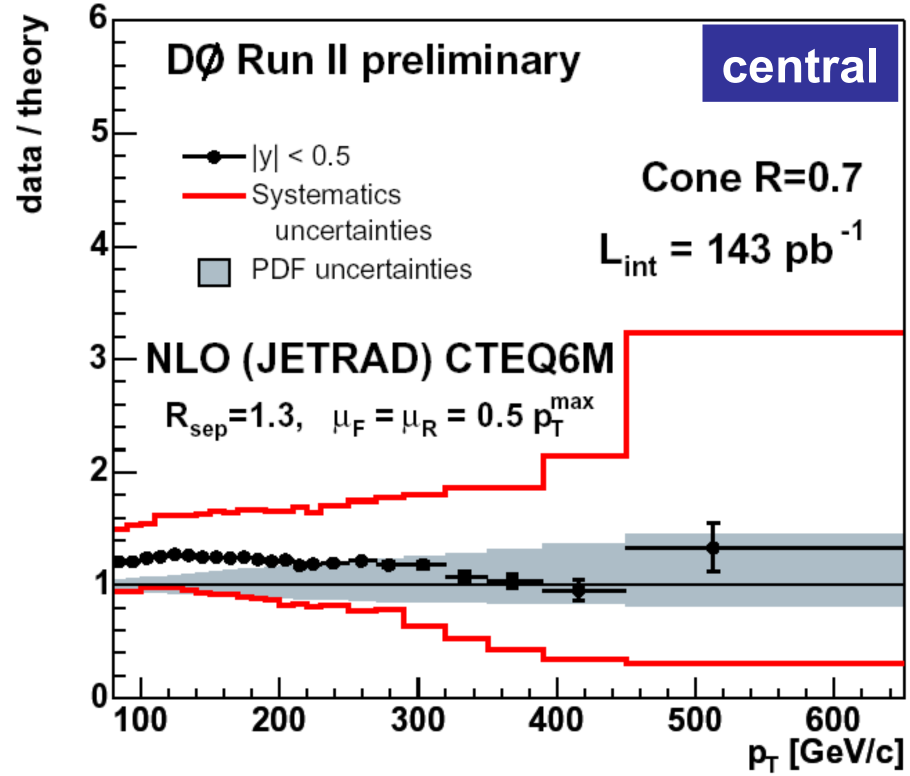
Inclusive jet cross section

Run I left an excess at high E_T (now attributed to high x contribution in the gluon PDF)

Central region is most sensitive to new physics and PDFs

Forward regions are less sensitive to new physics but still sensitive to PDFs

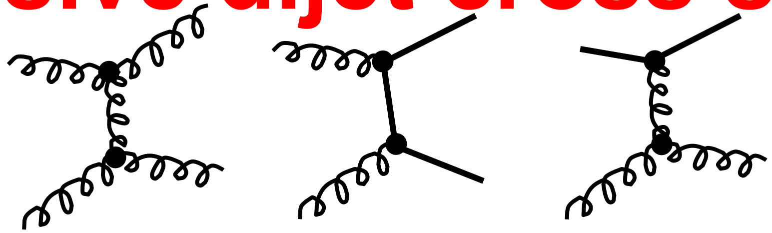


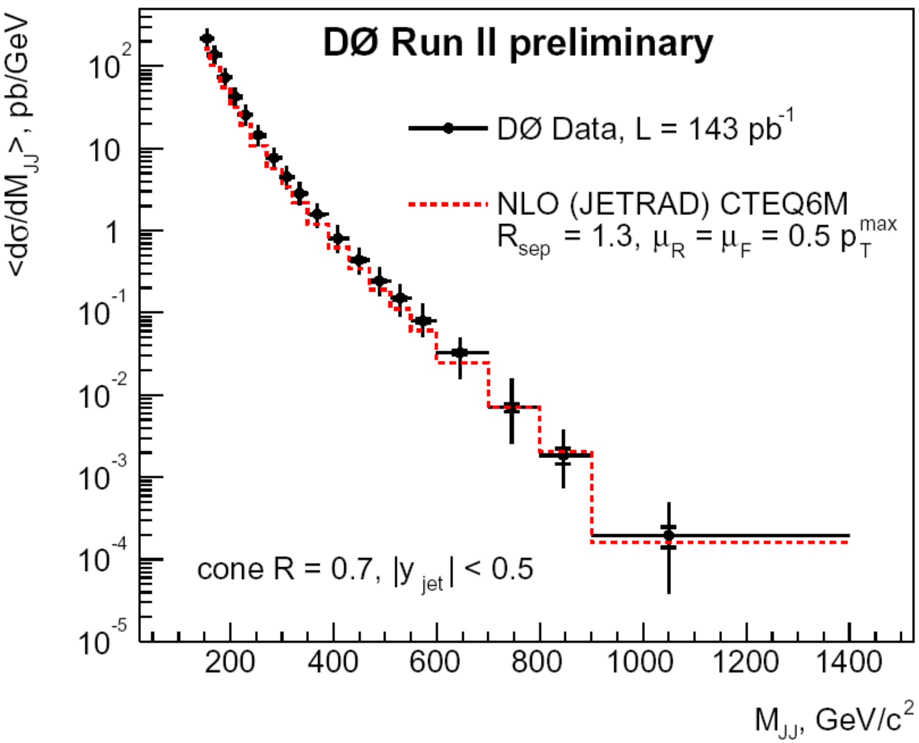


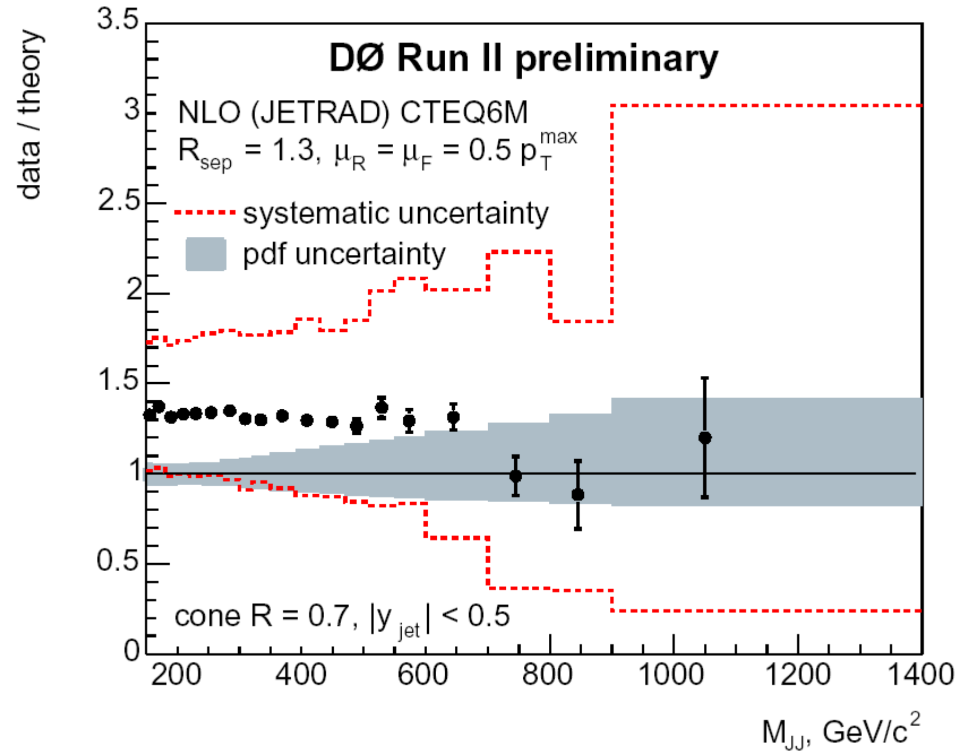
Data and theory agree within errors for all rapidity-regions

Experimental uncertainties dominated by Jet Energy Scale (JES)

Inclusive dijet cross section





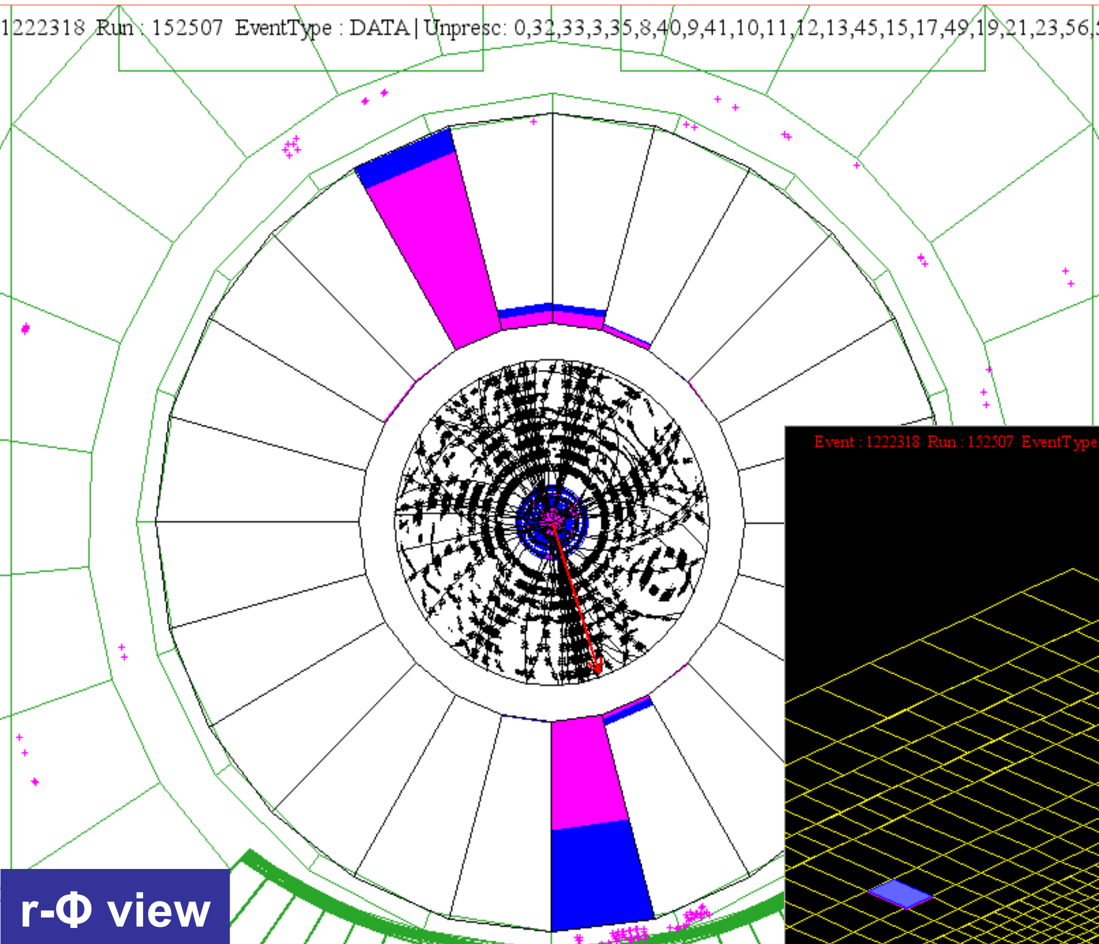


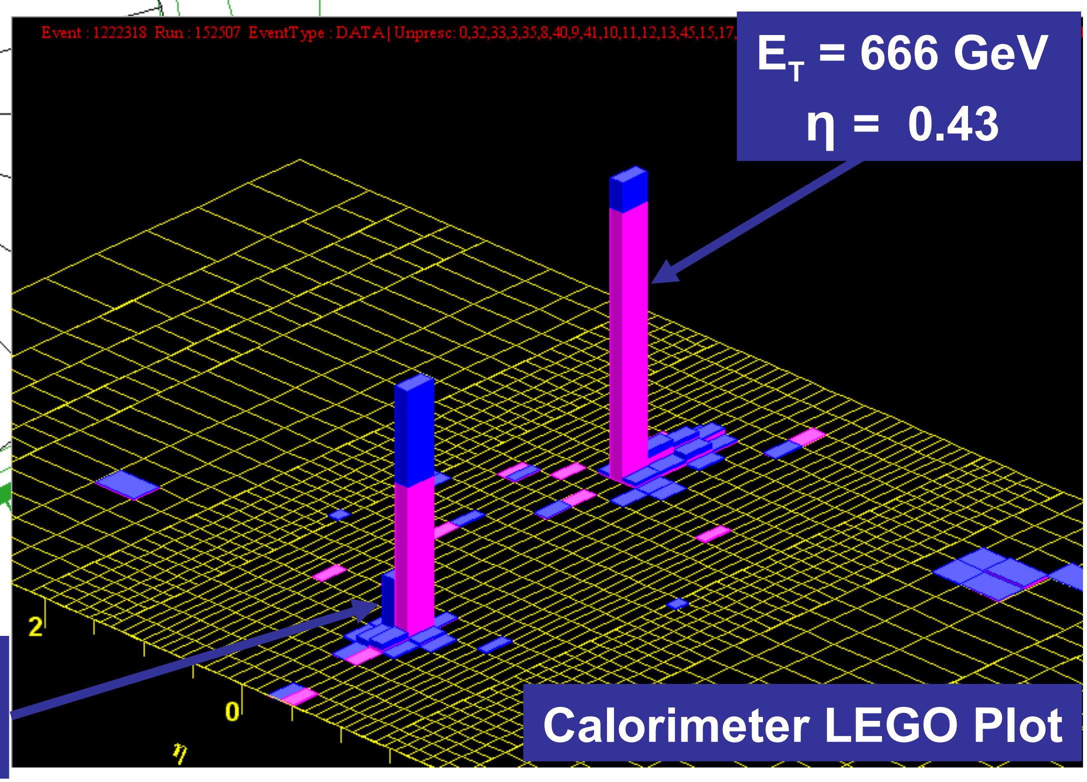
Data is well described by NLO MC throughout the whole kinematic region

Now working on improving the Jet Energy Scale uncertainty

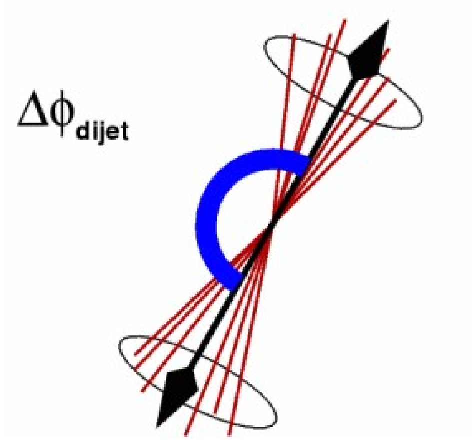
Highest mass dijet event

Recorded by CDF:
Mass = 1364 GeV/c^2





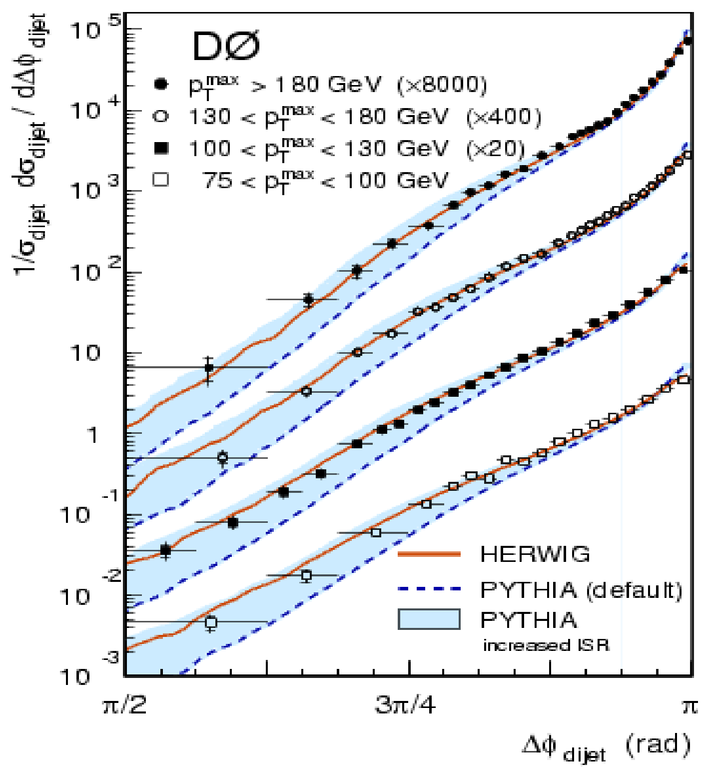
Jet studies: azimuthal decorrelation



- ► DØ has measured $\Delta\Phi_{dijet}$ in two jet events
- ► At higher orders of α_s^2 additional jets induce azimuthal decorrelation:

$\Delta\Phi_{dijet}<\pi$ indicates additional hard radiation

$$\lim_{p_{T3}\to 0} \Delta\phi_{dijet} = \pi$$

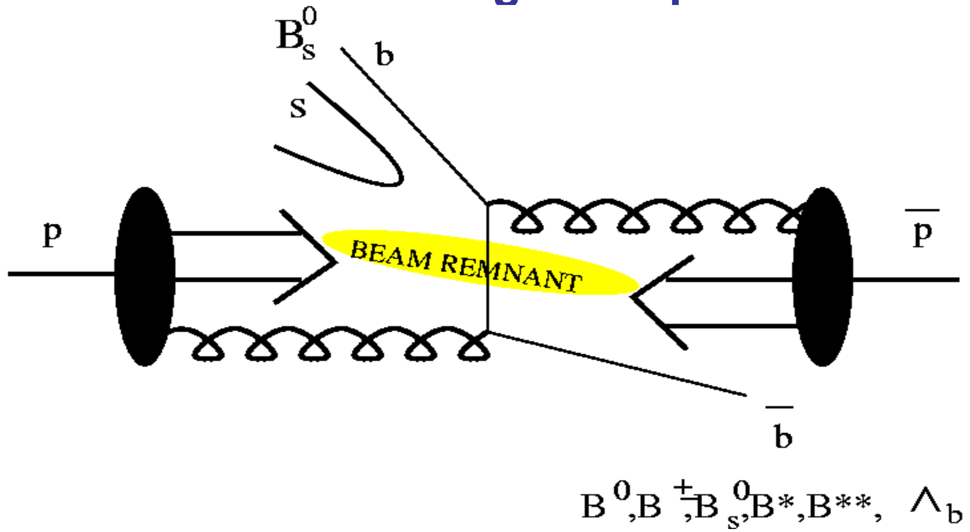


- ► $\Delta\Phi_{dijet}$ is sensitive to jet formation without having to measure the third jet directly
- ► Meas. $d\sigma/d\Delta\Phi_{dijet}$ incompatible with LO MC
- ► NLO pQCD agrees well in all kinem. regions
- ► "Tuned" (for underlying event) Pythia gives best agreement

B-physics

The study of B-hadrons is challenging at a hadron collider:

The bb production cross section is huge ~100μb and all B species are produced…



B_s and Λ_b not accessible at b-factories

… But huge inelastic cross section: S/B ~ 10^{-3}

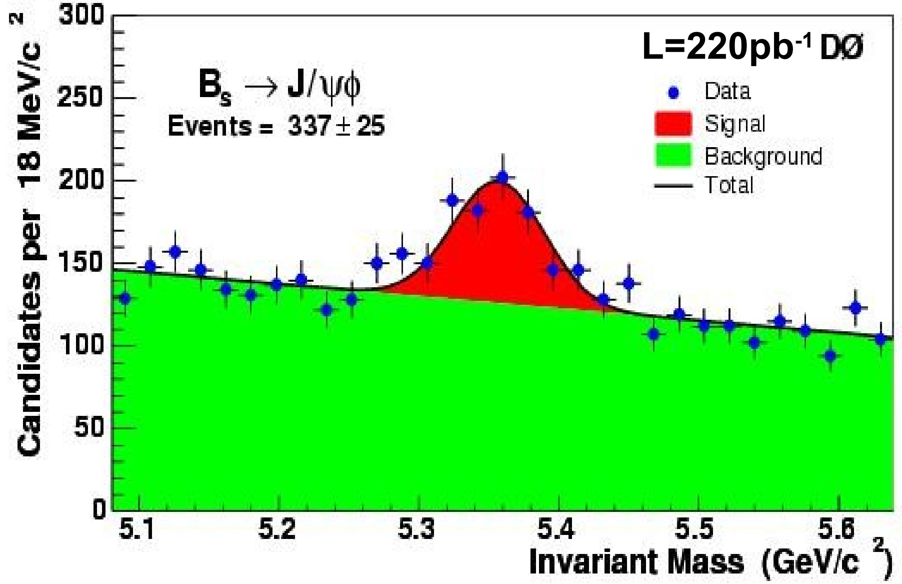
Need specialized triggers:

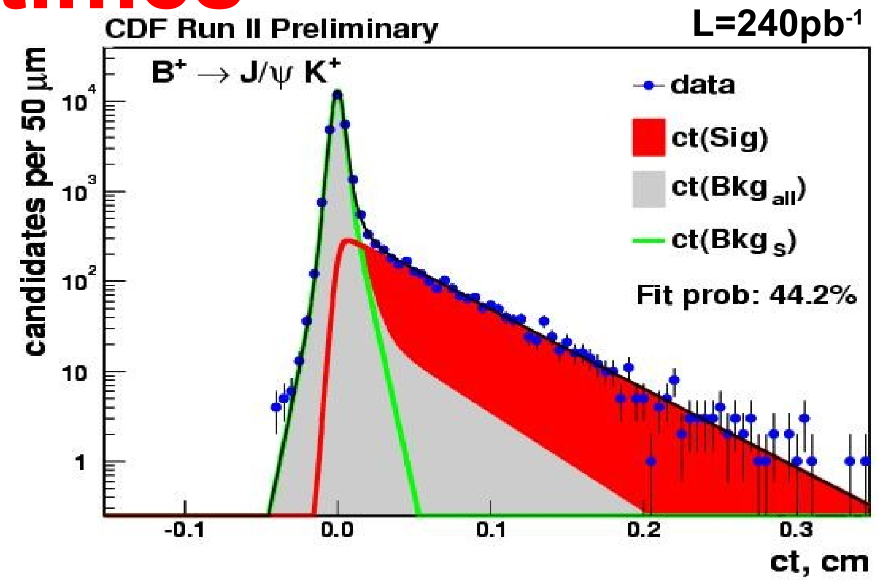
► Single lepton triggers

► Dilepton triggers such as $J/\psi \rightarrow \mu^+ \mu^-$

► L2 trigger on displaced tracks using SVX allows CDF to trigger purely hadronic B decays such as $B_0 \rightarrow \pi^+\pi^-$, $B_s \rightarrow D_s^- \pi^+$ ...

B-lifetimes





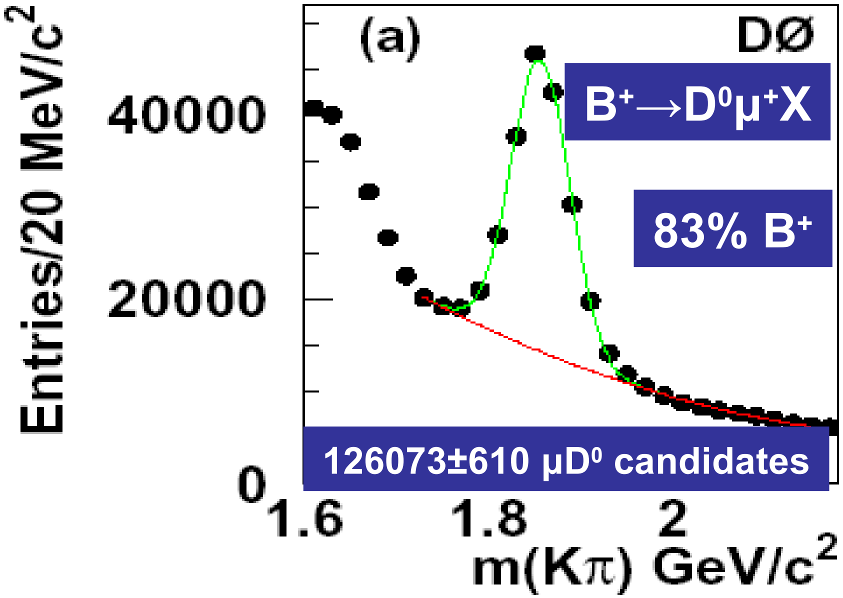
DØ has collected the world's largest sample of exclusive $B_s \rightarrow J/\psi\Phi(\rightarrow K^+K^-)$ and has the single most precise measurement:

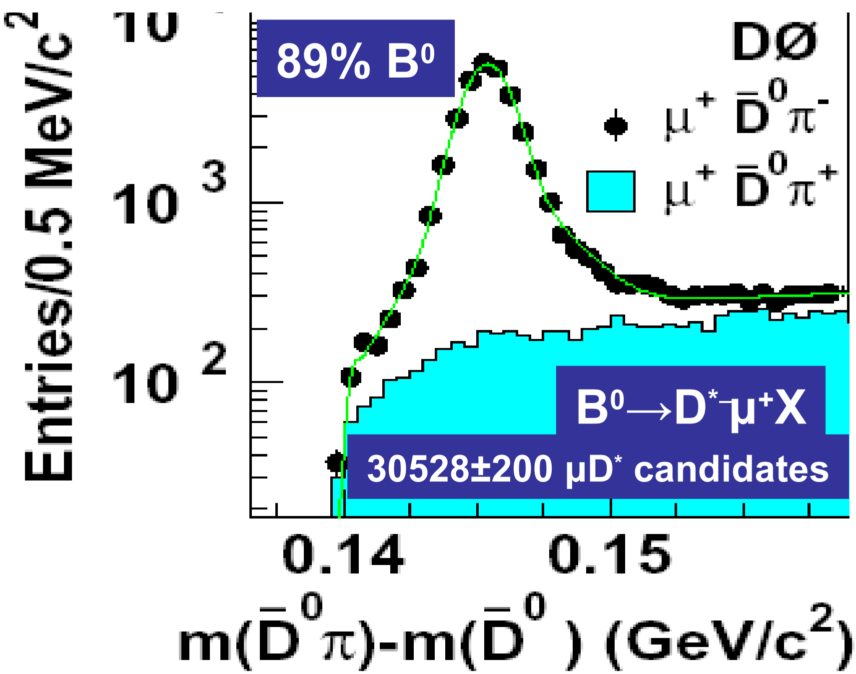
$$\tau(B_s^0) = 1.444^{+0.098}_{-0.090}(stat) \pm 0.020(sys)\, ps$$

CDF is competitive in all B lifetimes due to excellent momentum and vtx resolution

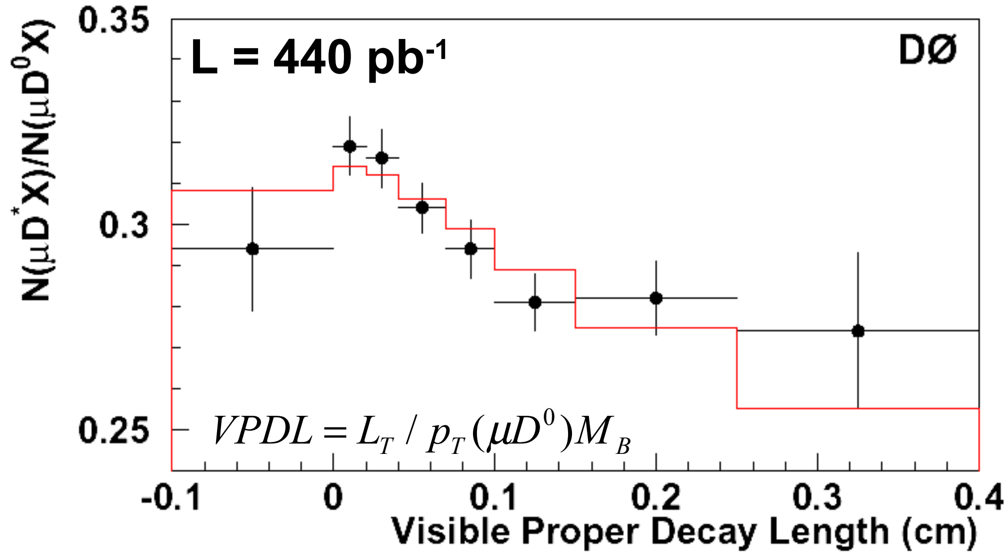
B-hadron	CDF measurement (ps)	PDG value (ps)	cτ (μm)
B^+	1.66 ± 0.03 ± 0.08	1.674 ± 0.018	502
B^0	1.54 ± 0.05 ± 0.08	1.542 ± 0.016	462
B_s	1.37 ± 0.10 ± 0.01	1.461 ± 0.057	438
Λ_b	1.25 ± 0.26 ± 0.10	1.229 ± 0.080	374

B lifetimes: $\tau(B^+)/\tau(B^0)$ ratio





Novel technique to measure $\tau(B^+)/\tau(B^0)$:
Measure directly the ratio $r=N(D^*\mu)/N(D^0\mu)$ at different decay distances:

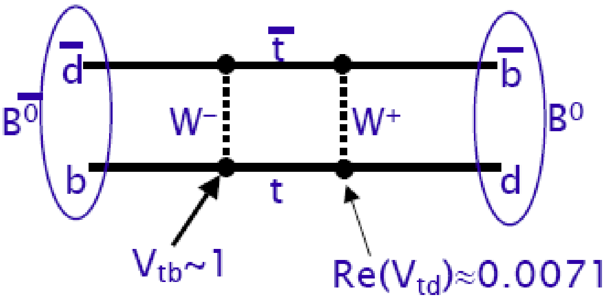


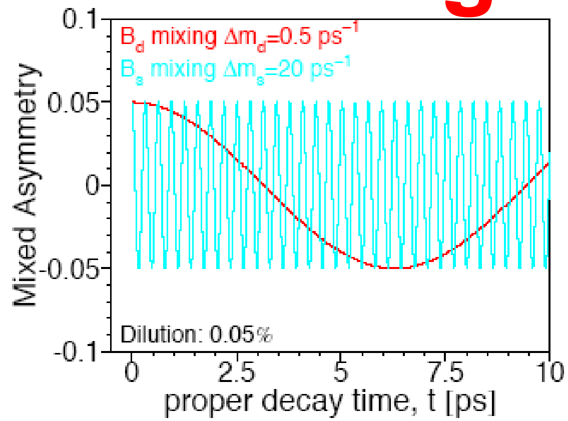
Use binned χ^2 fit of event ratios:

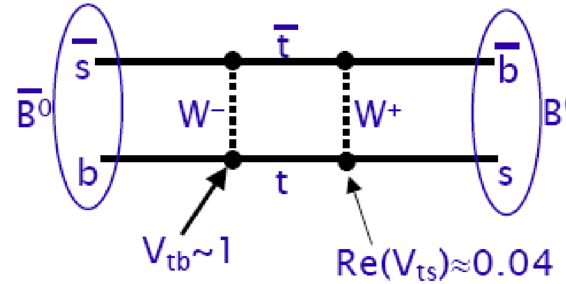
$\tau(B^+)/\tau(B^0) = 1.080 \pm 0.016(stat) \pm 0.014(sys)$

World's most precise measurement!
World average: 1.086 ± 0.017

B mixing







B_d fully mixes in about 4.1 lifetimes

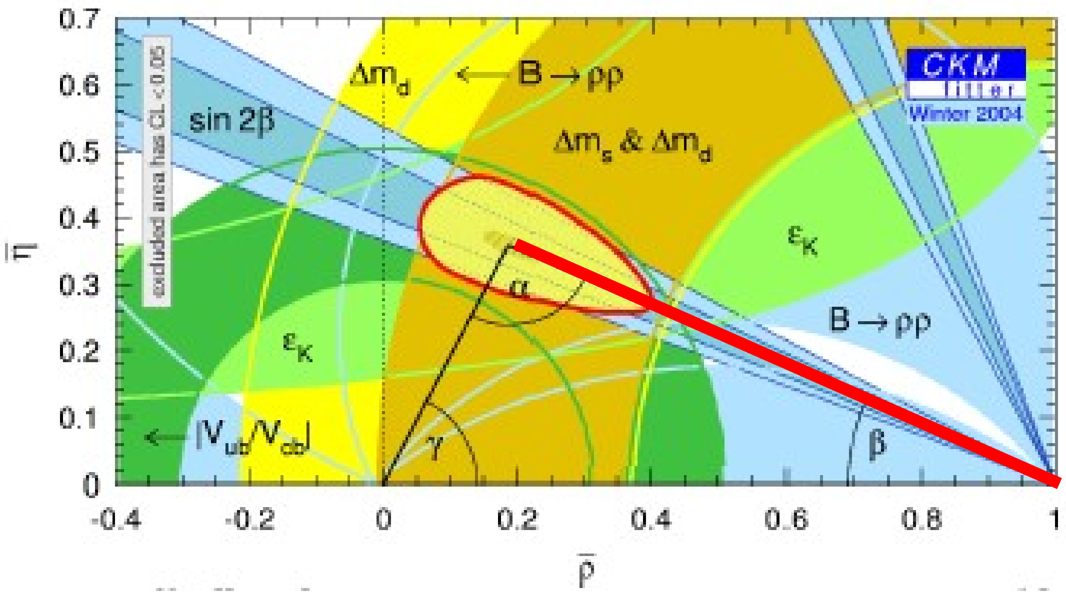
Δm_d = 0.502± 0.006 ps^{-1} (world comb.)

Measured with great precision by Belle & BaBar

B_s fully mixes in <0.15 lifetimes!!

Δm_s > 14.4 ps^{-1} 95%CL (world comb.)

Only reachable at hadron colliders



Hadronic uncertainties cancel in ratio:

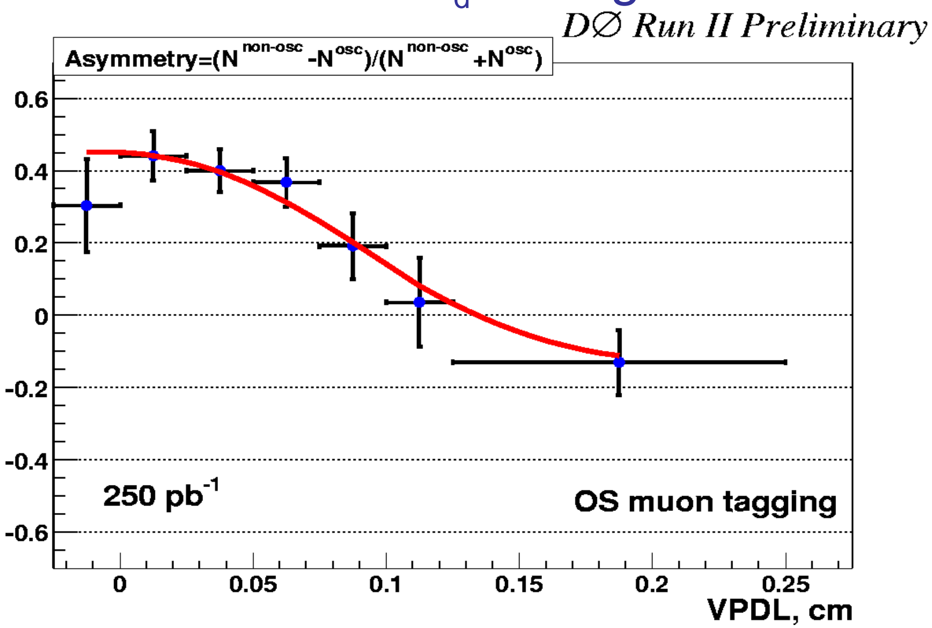
$$\frac{|V_{td}|}{|V_{ts}|} = 1.0\,\xi\,\sqrt{\frac{\Delta m_d}{\Delta m_s}}$$

from LATTICE

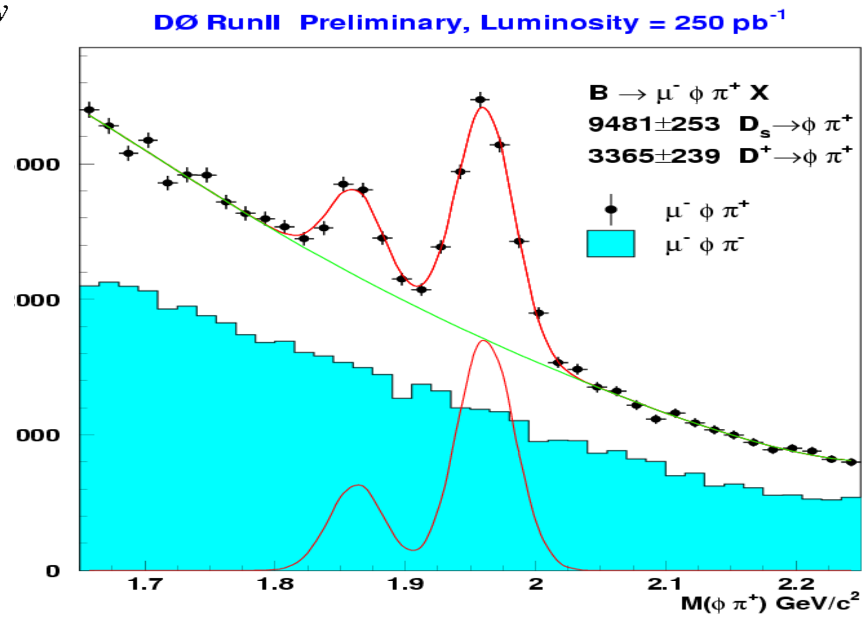
► New physics can affect $\Delta m_d/\Delta m_s$

Towards B_s mixing at DØ

- Demonstrate B_d mixing



2. B_s sample: $B_s \to (D_s \to \phi\pi)\mu\nu$



DØ uses its large sample of semileptonic B_d decays to measure the oscillation frequency:

$$\Delta m_d = 0.506 \pm 0.055(stat) \pm 0.049(syst)\, ps^{-1}$$

Use opposite side muon to tag initial state:

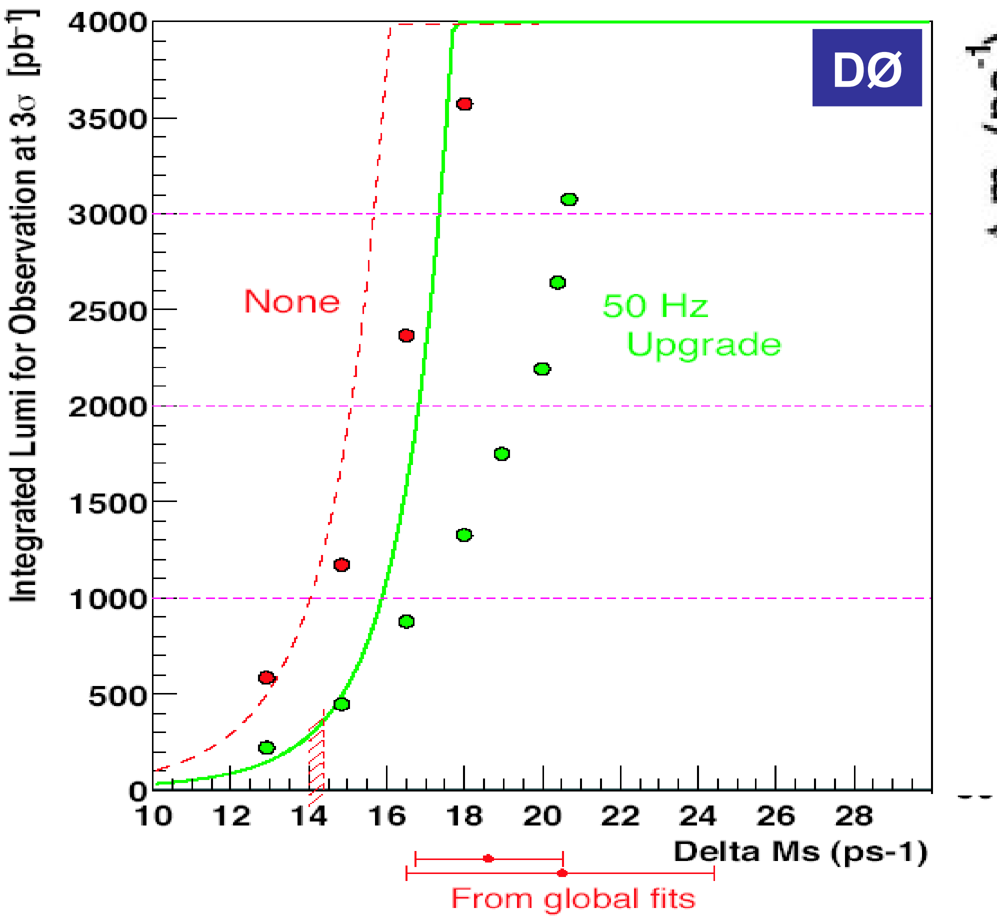
► Same lepton charge for oscillated mesons

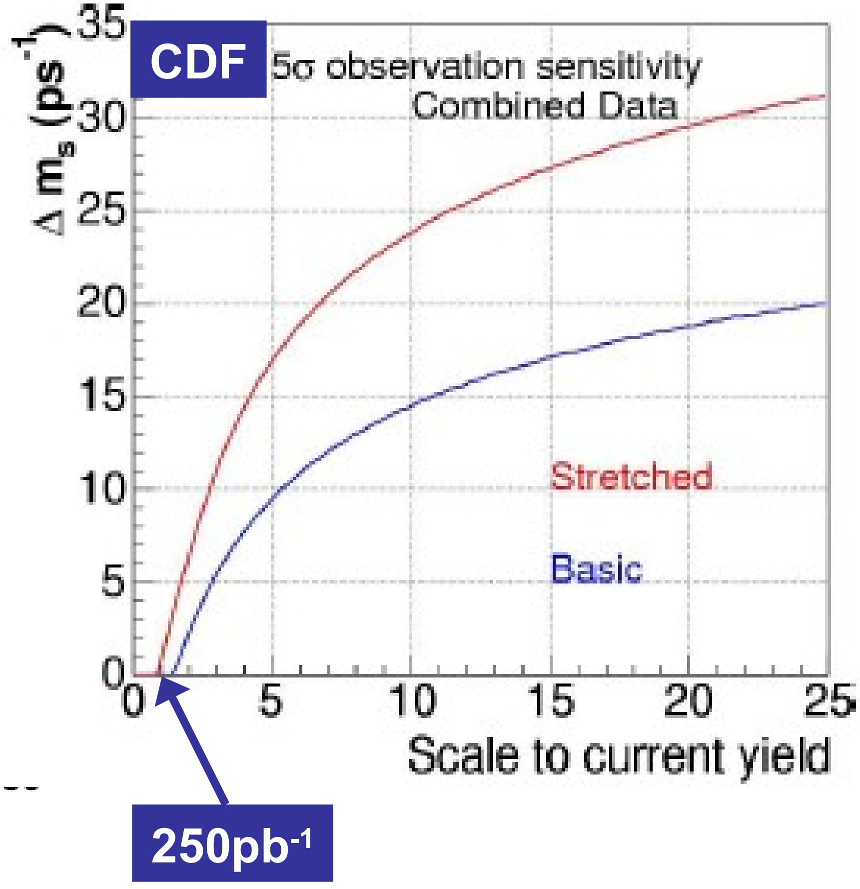
► Opposite lepton charge for non-oscillated mesons

3. Upgrade L3DAQ and Si layer 0

IU and OU have put forward $500k for a dedicated 50Hz B trigger bandwidth upgrade with offsite reconstruction farm. Awaiting DOE/NSF match.

B_s mixing reach





Semileptonic decays:

- ►Very good statistics but poorer time resolution
- ►If $\Delta m_s \cong$ 15 ps^{-1} expect a 1-2 σ measurement with 500 pb^{-1}

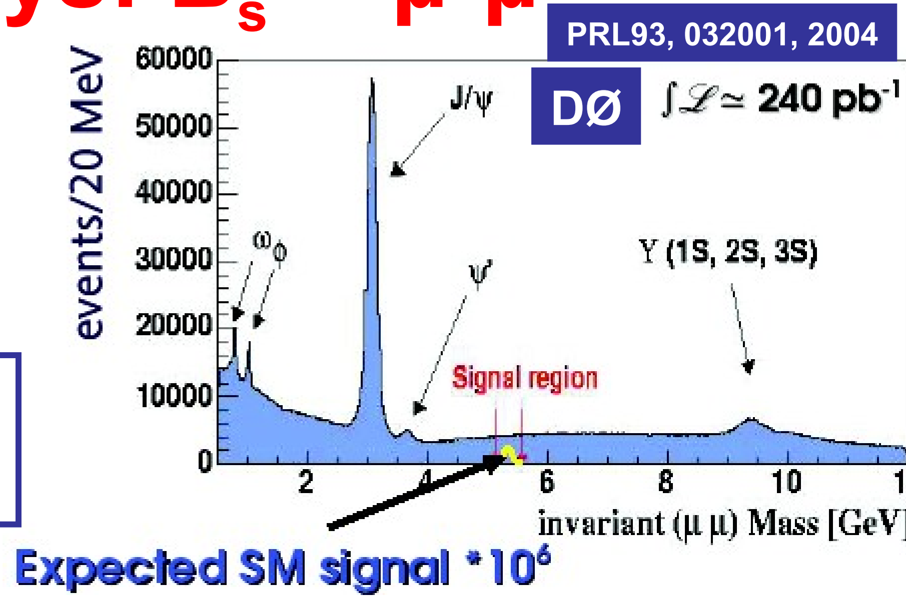
Fully reconstructed hadronic decays:

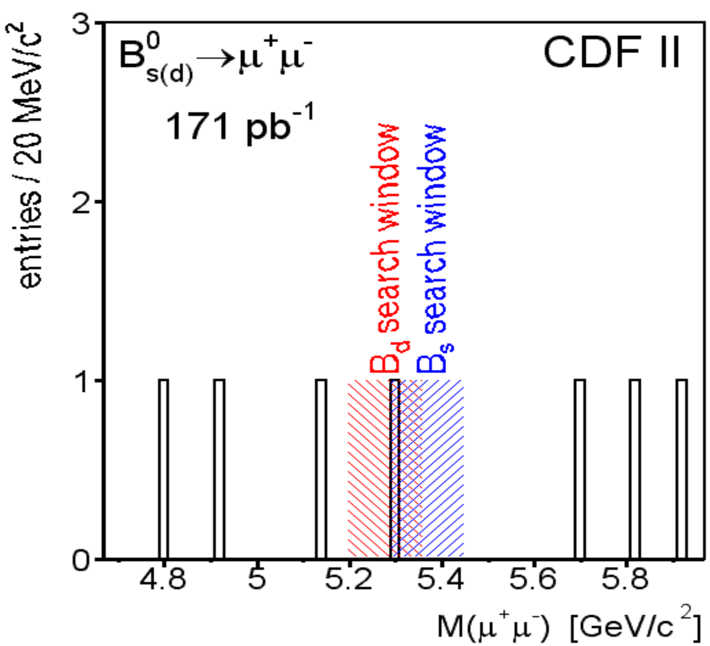
- ►Poorer statistics, excellent time resol.
- ►CDF: 5σ observation of Δm_s= 24 ps^{-1} with ~2.5 fb^{-1}

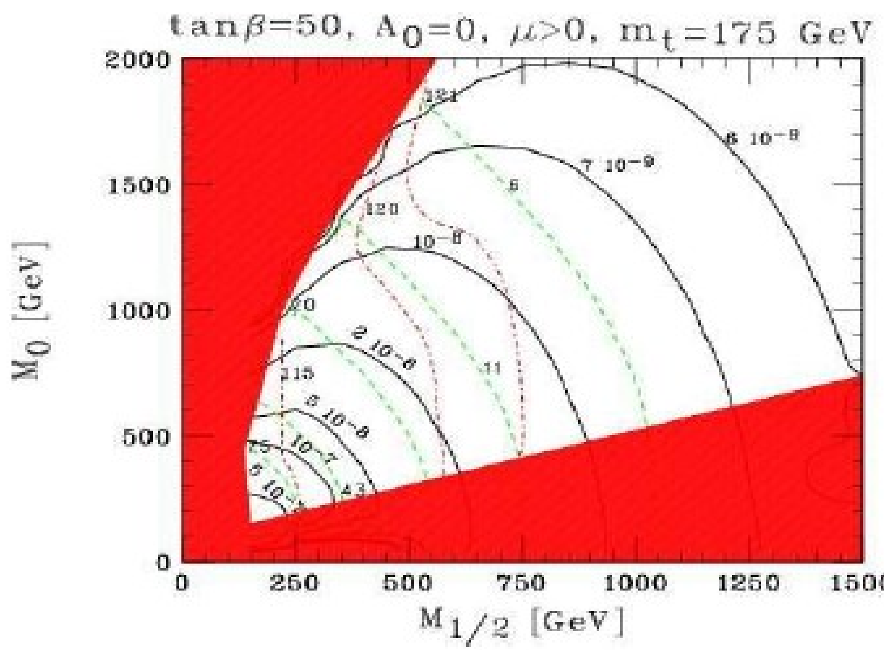
Rare B decays: $B_s \rightarrow \mu^+\mu^-$

- ► **SM prediction:**
  $BR(B_s \rightarrow \mu^+\mu^-) = (3.4 \pm 0.5) \cdot 10^{-9}$
- ► **SUSY predicts an enhancement of 2-3 orders of magnitude at high tanβ**

DØ (240pb^{-1}): BR<$3.8 \cdot 10^{-7}$ @ 90%C.L.
CDF (171pb^{-1}): BR<$5.8 \cdot 10^{-7}$ @ 90%C.L.

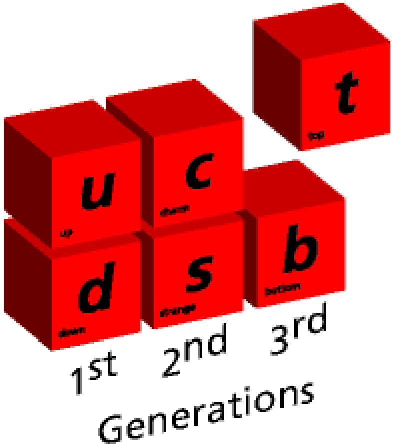




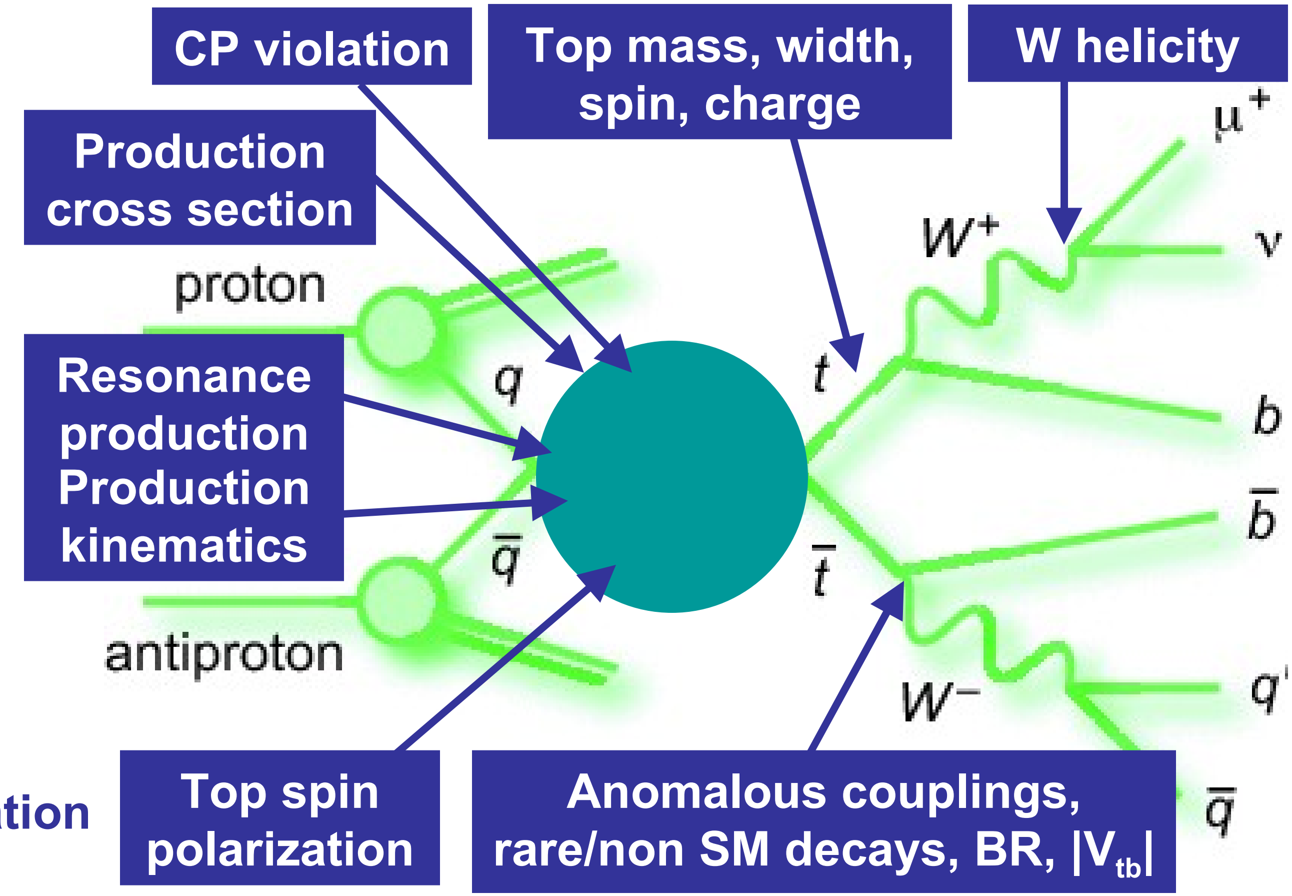


These limits start to impact MSSM scenarios.

Intersecting the m_H =115 GeV contour



Top quark physics in Run II



The Tevatron is the world's only source of top quarks!

Top quark has a special place in the SM: $M_t \sim v/\sqrt{2}$
Window into EWSB?

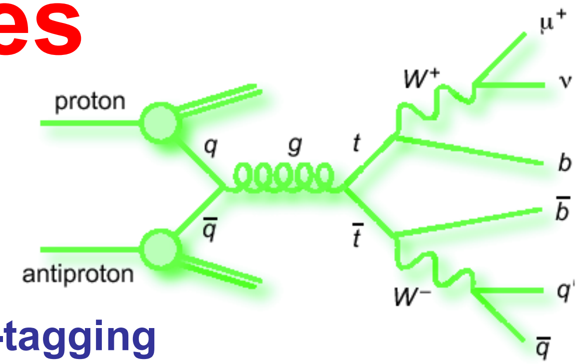
Decays before hadronization

Still know very little experimentally about the top quark

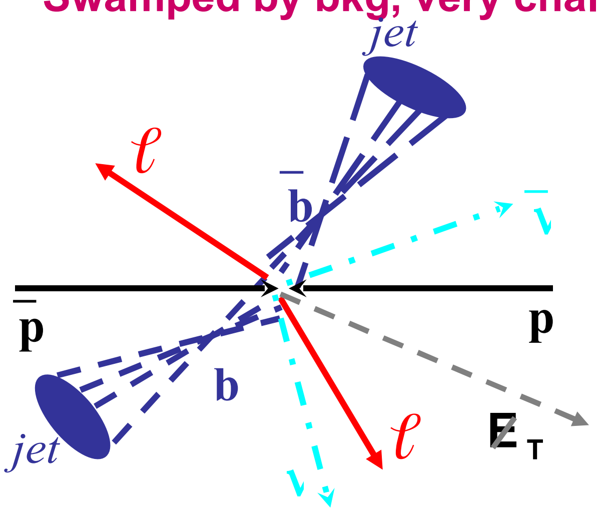
Run I:
Identified ~100 top events

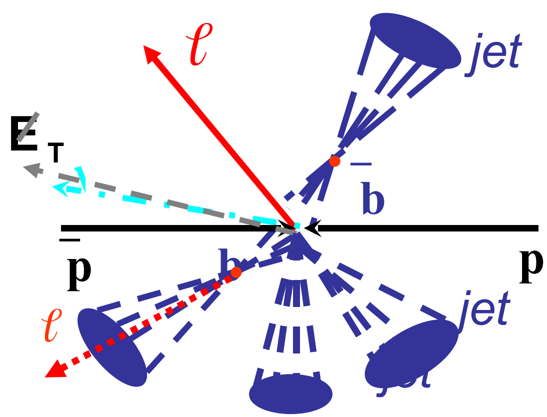
Top decay modes

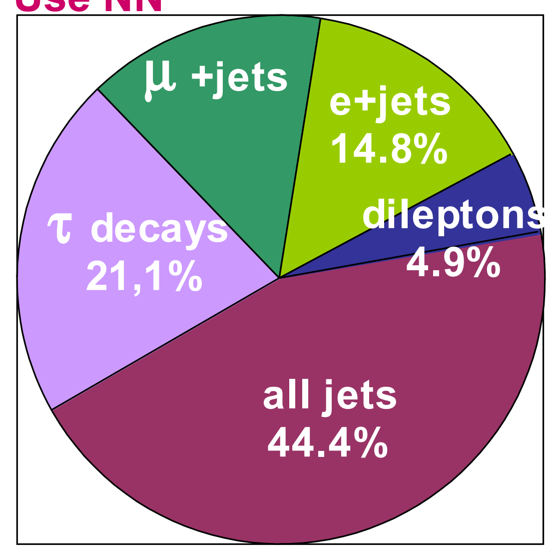
In the SM: BR($t \rightarrow Wb$)~100%
Classify topologies according to W decays from ttbar:



- **dilepton: 2 high p_T leptons, 2 *b*-jets, large E_T^{mis}**
  - Small BR, but cleaner signal and small systematics. No *b*-tagging
  - Physics bkgs: WW/WZ, DY
  - Instrumental: fake leptons in W+jets and QCD and fake E_T^{miss}
- **lepton+jets: 1 high p_T lepton, 4 jets (2 *b*'s), large E_t^{miss}**
  - Larger yield, larger bkg ⇒ Use event topology, *b*-tagging (and SLT)
  - Backgrounds: W+jets and fake leptons in QCD
- **all jets: 6 jets (2 *b*'s)**
  - Swamped by bkg, very challenging, but impossible at LHC! Use NN



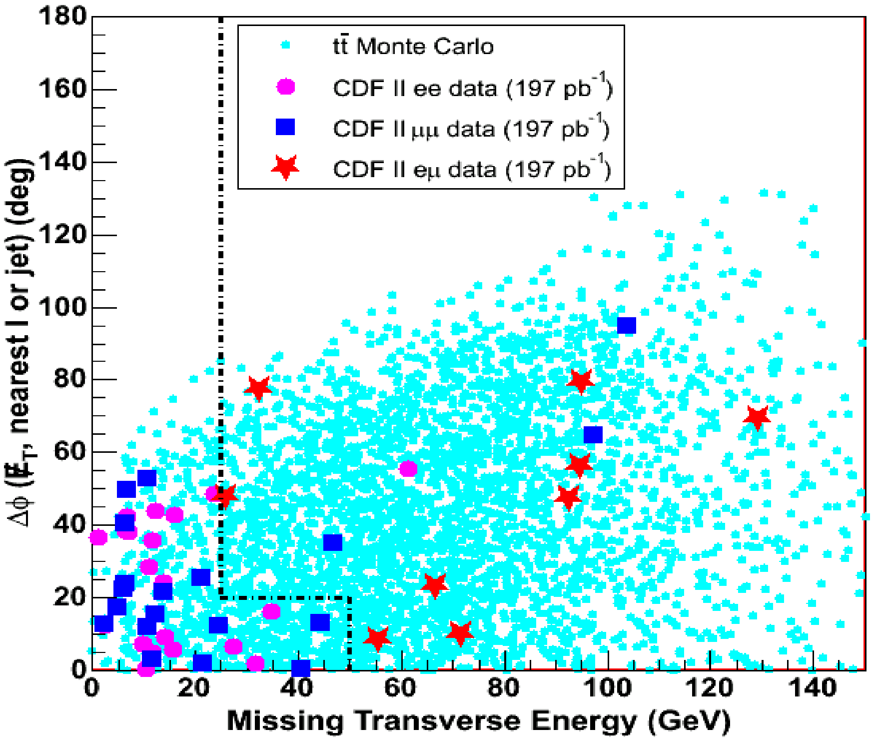


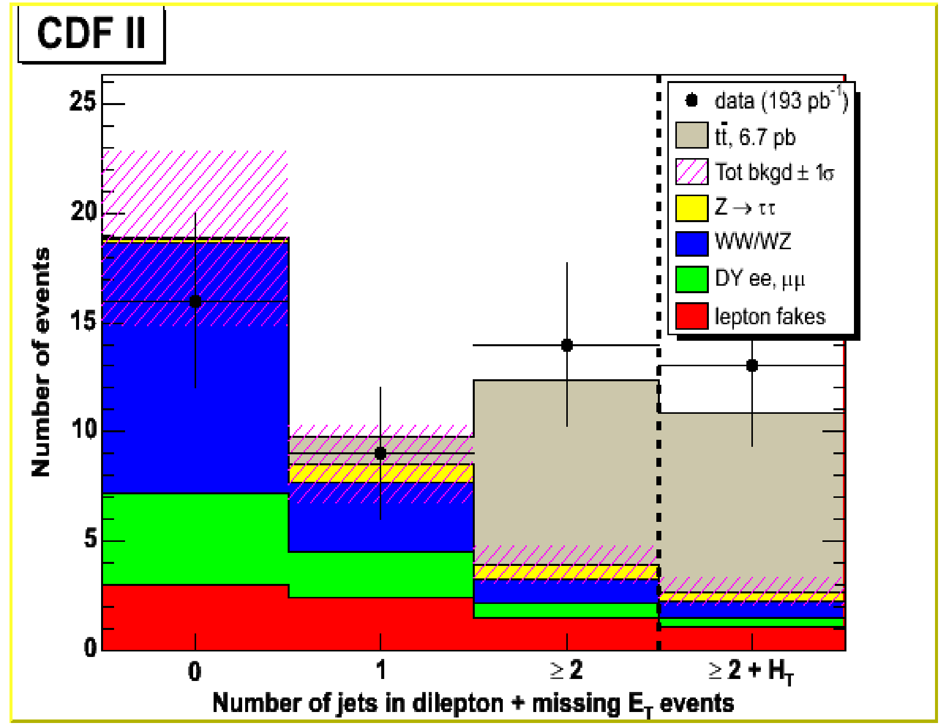


Top dilepton cross section

hep-ex/0404036

$$\sigma(t\bar{t}) = 7.0^{+2.4}_{-2.1}(stat)^{+1.6}_{-1.1}(syst) \pm 0.4(lum)\ \mathrm{pb}$$





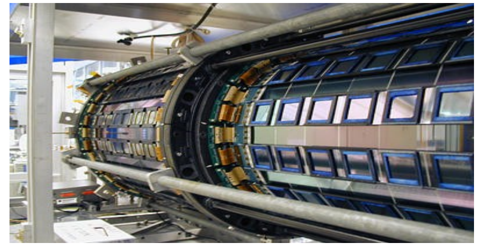
Flavor distribution is consistent with expectation (there was an excess of eμ in CDF I)

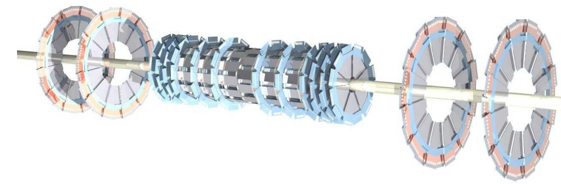
Error is statistics dominated

Both experiments clearly re-establish top signal!

	ee	μ μ	e μ
Observed	1	3	9
Expected	3.3±0.5	2.8±0.5	6.8±0.8

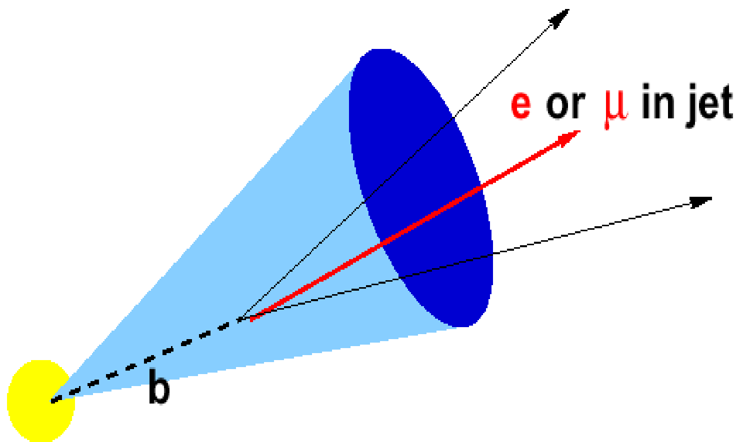
Tagging b-jets





B-mesons can decay semileptonically

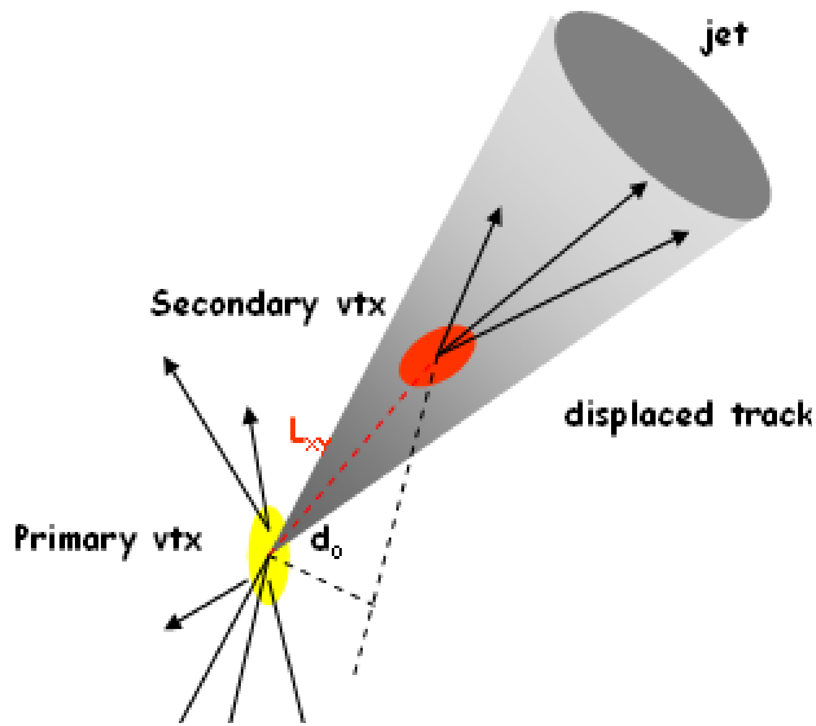
►Identify low-p_T muon from decay



- $b \to \ell\nu c$ (BR $\sim$ 20%)
- $b \to c \to \ell\nu s$ (BR $\sim$ 20%)

B-mesons are long-lived and massive

►Identify vertex of displaced tracks

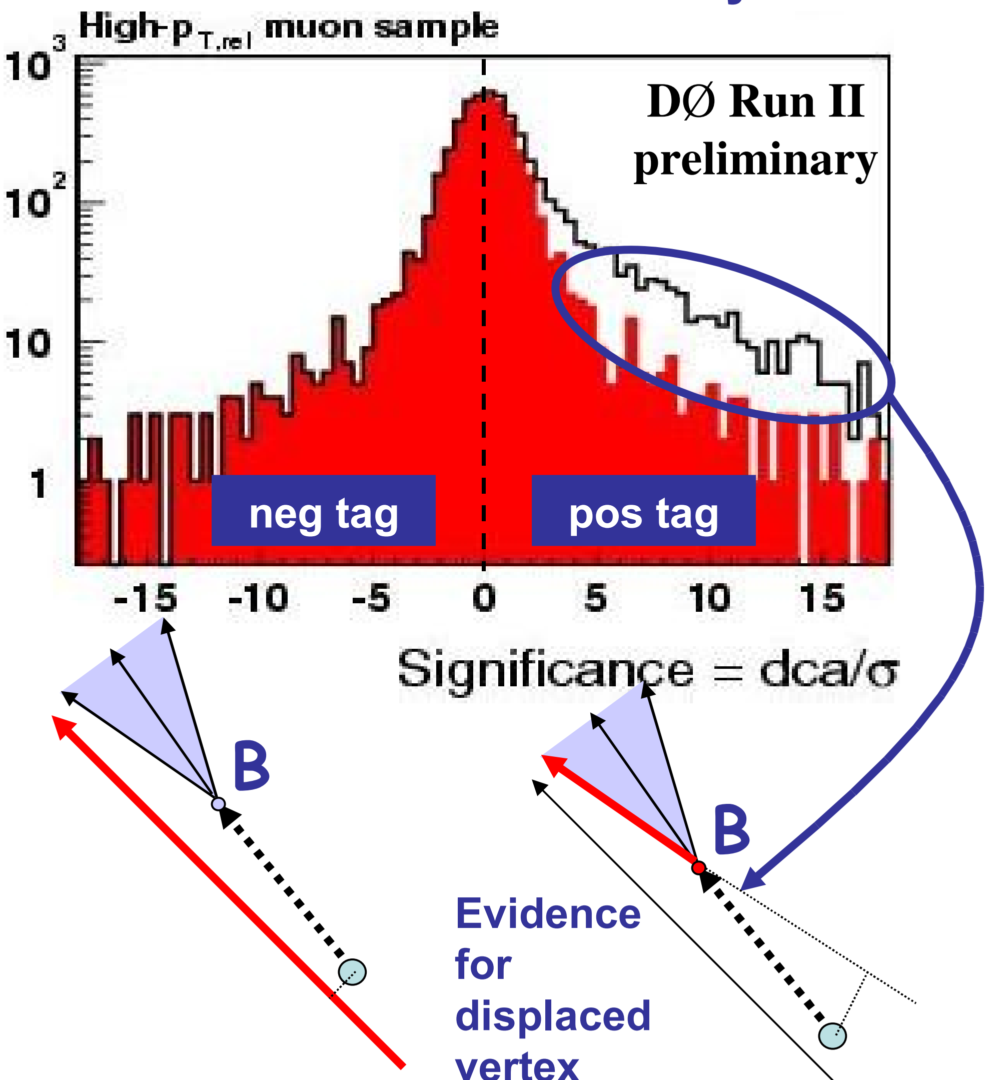


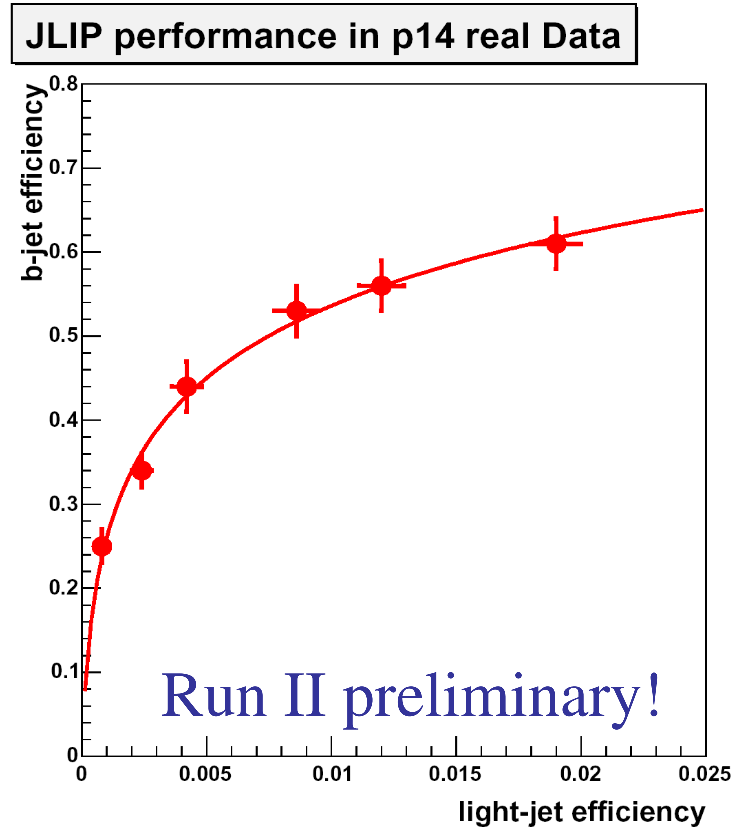
Both experiments can tag b-jets with up to 55% efficiency for 0.5% fake rate tag (SVX)

Lifetime *b*-tagging

DØ has three different algorithms (now working on combined NN tagger):

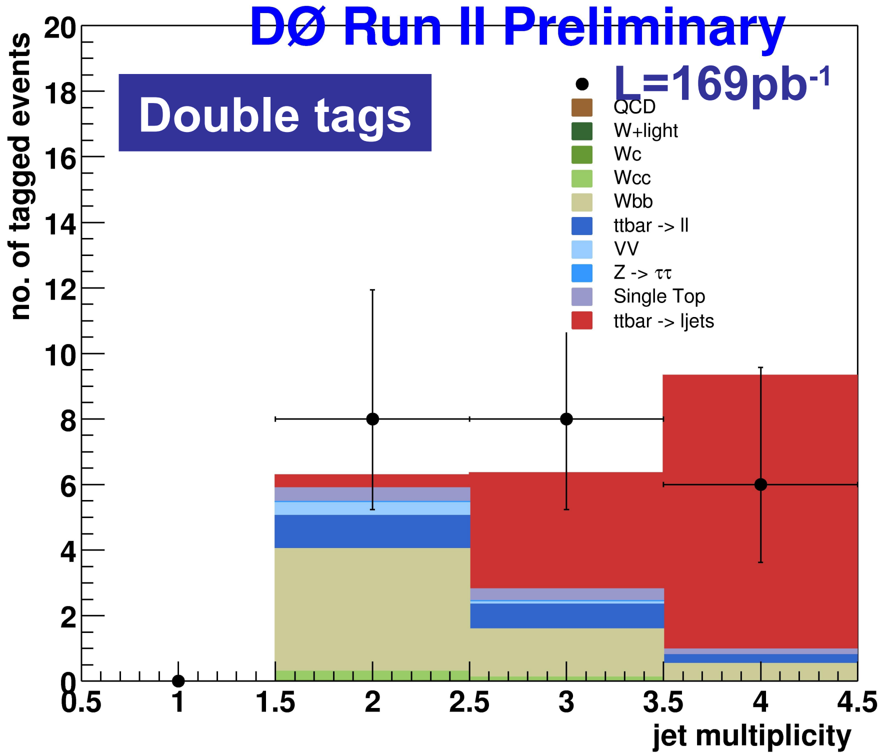
- Two based on tracks with large IPs
- One based on secondary vertices

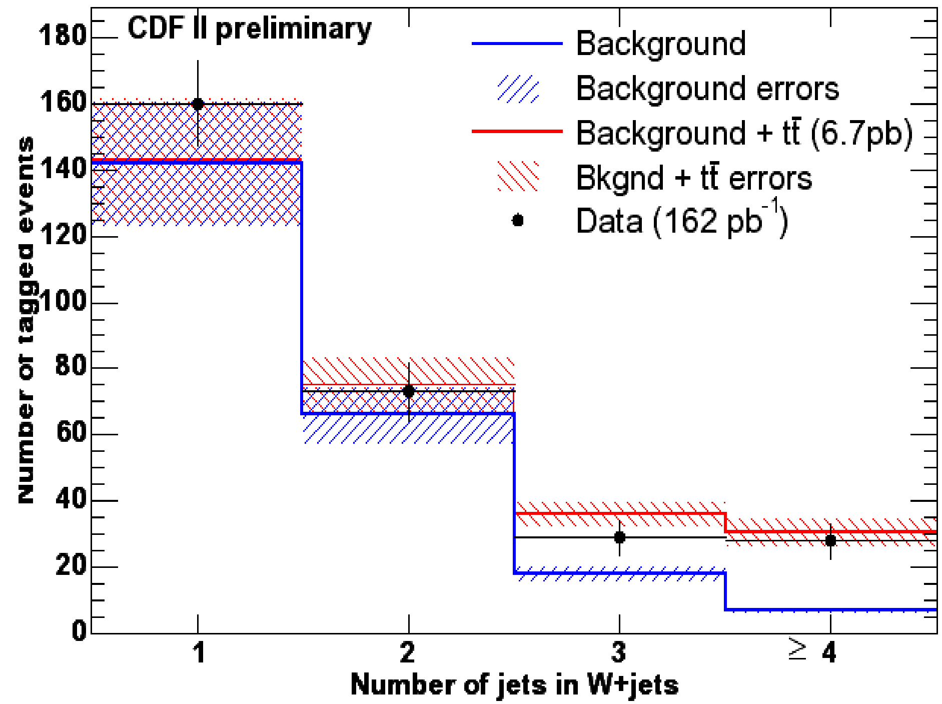




~ 50% *b*-tagging eff at a fake rate of 1%, to be compared with ~60% for MC ⇒ Improvements to be made by tuning the algorithms

SVX Tagged Top ℓ+jets cross section





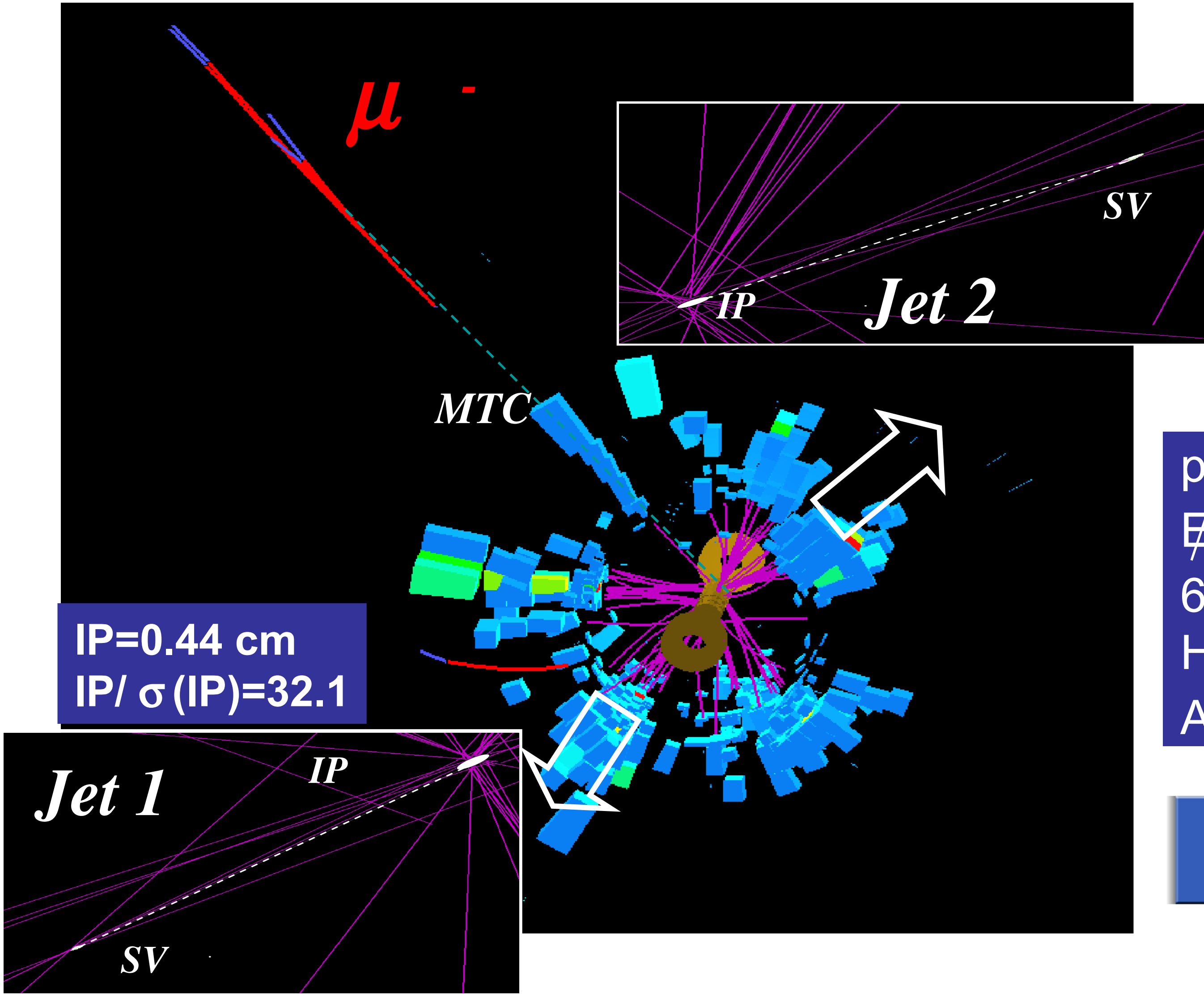
$$\sigma(t\bar{t}) = 8.2^{+1.3}_{-1.3}(stat)^{+1.9}_{-1.6}(syst) \pm 0.5(lumi)\ \text{pb}$$

$$\sigma(t\bar{t}) = 5.6^{+1.2}_{-1.1}(stat)^{+0.9}_{-0.6}(syst)\ \text{pb}$$

Use MC for diboson and W+heavy flavor estimates

Use data for non-W QCD and fake tags

Doubly tagged μ+jets event



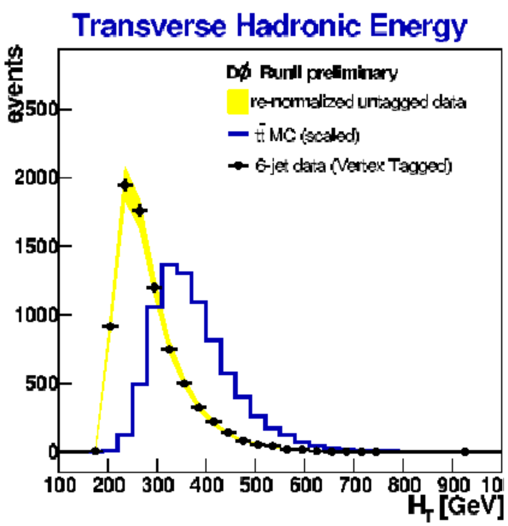
IP=0.53 cm
IP/ σ (IP)=14.9

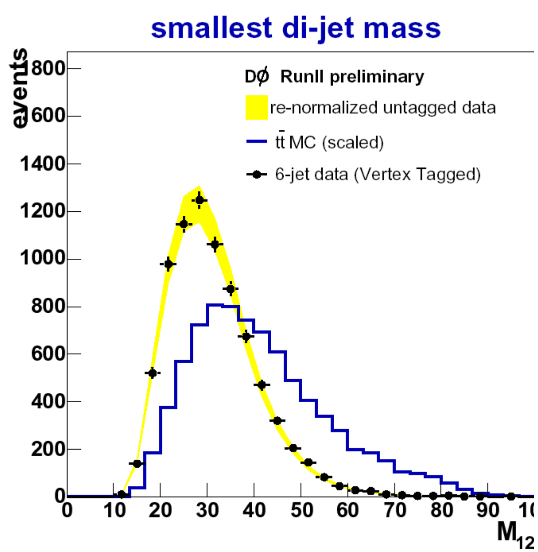
IP=0.44 cm
IP/ σ (IP)=32.1

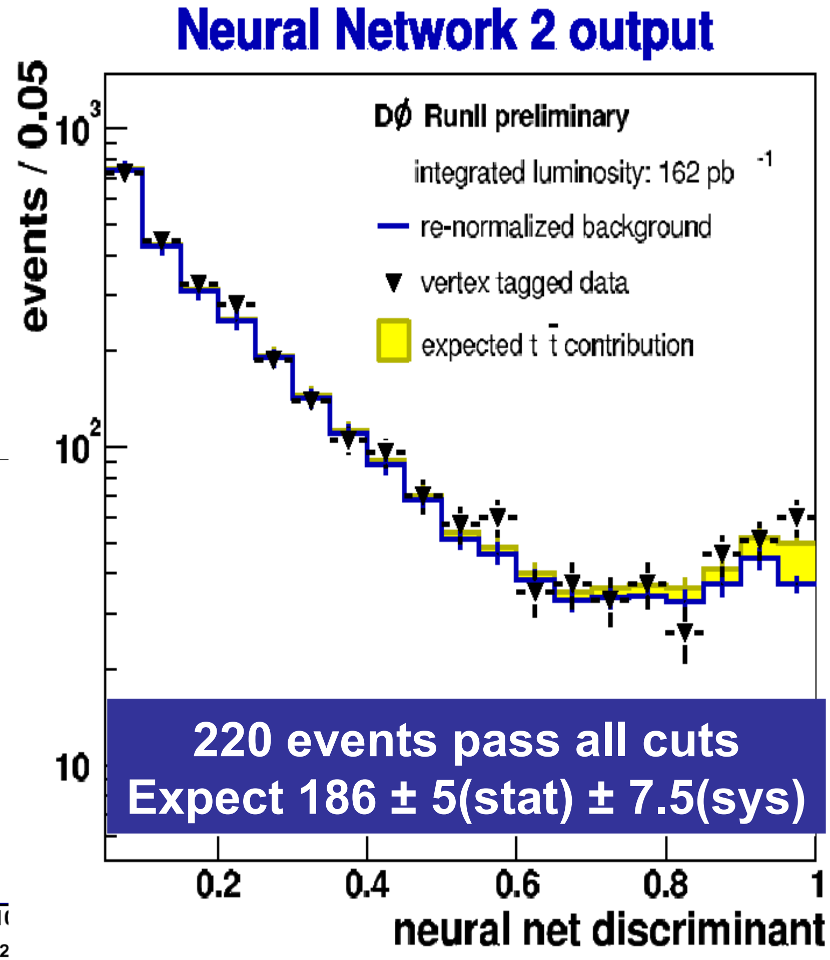
$p_T(\mu)$ = 47.9 GeV
$\not{E}_T$= 55.1 GeV
6 jets
H_T = 482 GeV
A = 0.16

Top all hadronic cross section

- ►QCD background is 3-4 orders of magnitude larger than signal
- ►Require one SVX tag
- ►Use Neural Network trained on MC for signal and data for background



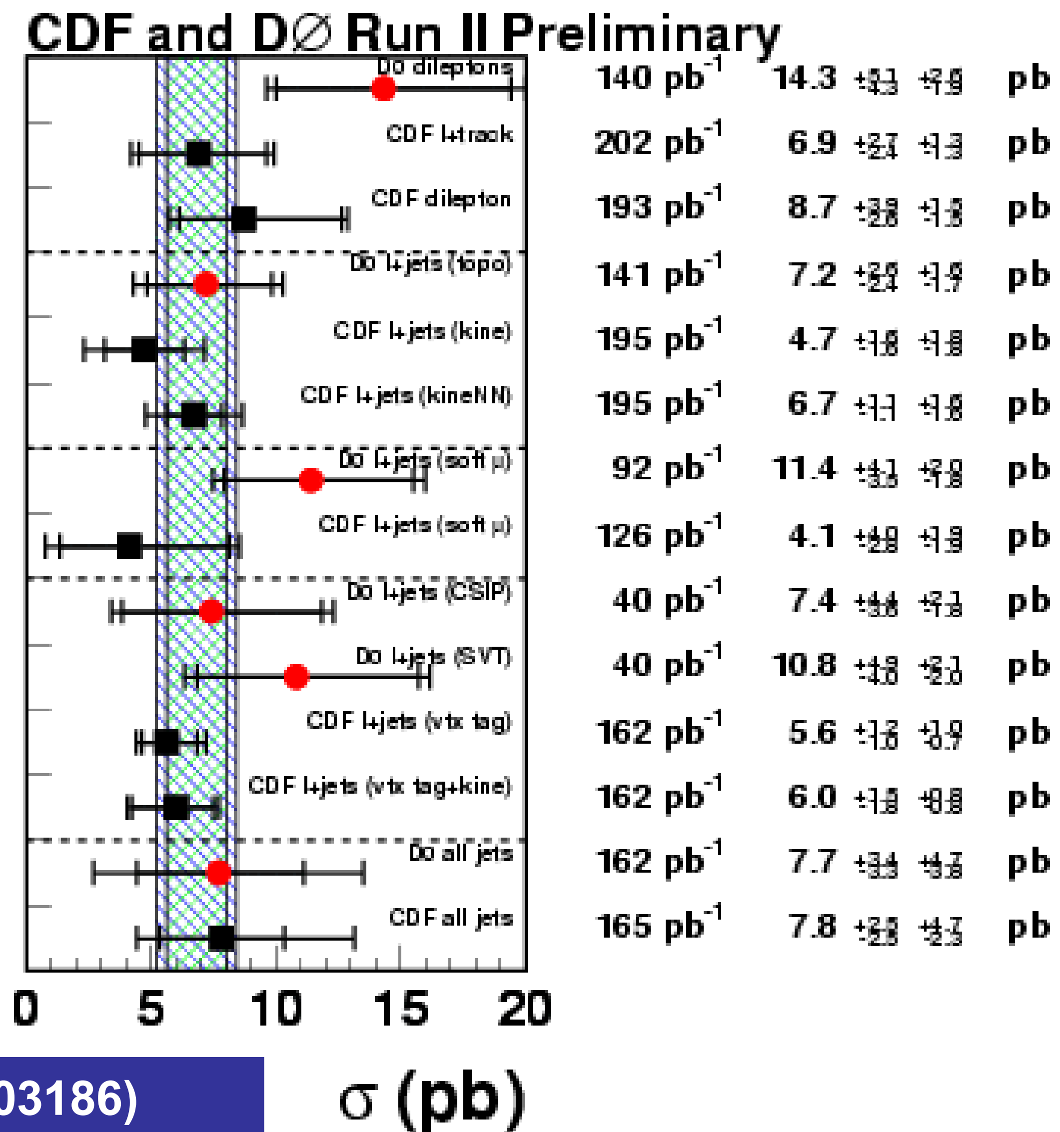




220 events pass all cuts
Expect 186 ± 5(stat) ± 7.5(sys)

$$\sigma(t\bar{t} \to 6j) = 7.7^{+3.4}_{-3.3}(stat)^{+4.7}_{-3.8}(syst) \pm 0.5(lum)\ \text{pb}$$

Top cross section measurements



Kidonakis (hep-ph/303186)
Cacciari et al. (hep-ph/0303085)

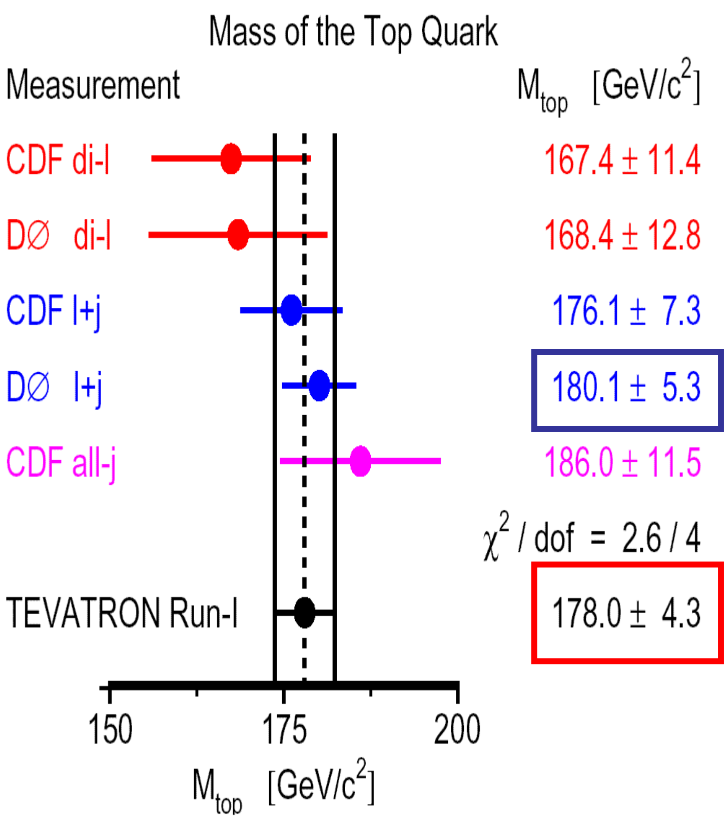
Top quark mass status

- ►All methods rely on templates for different top mass hypothesis
- ►Build templates which predict the distribution of an observable that depends on m_t
- ►This "mass estimator" can be:
  - ►Single number like reconstructed top mass from kinematic fit
  - ►Continuous curve: matrix element method using individual event probabilities

DØ Run I ℓ+jets top mass with reduced statistical uncertainty from multidimensional probabilistic estimator has been included on a new Run I Tevatron combination (hep-ex/0404010):

Old Run I TeV m_t = 174.3±3.2±4.0 GeV/c^2

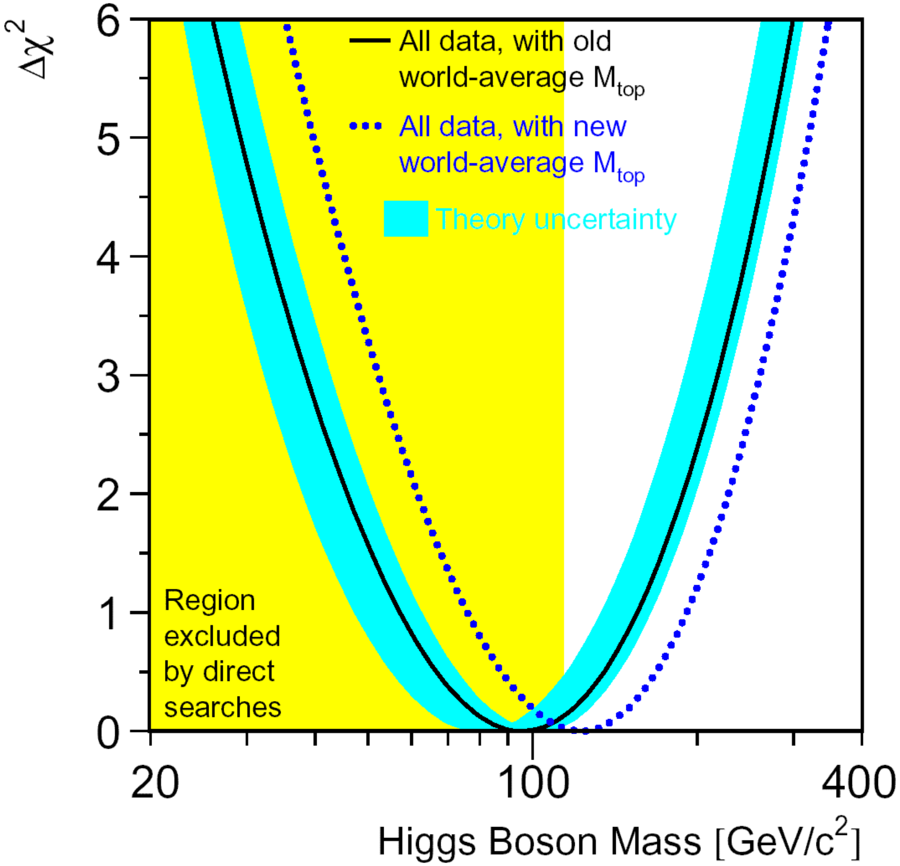
New Run I TeV m_t = 178.0±2.7±3.3 GeV/c^2

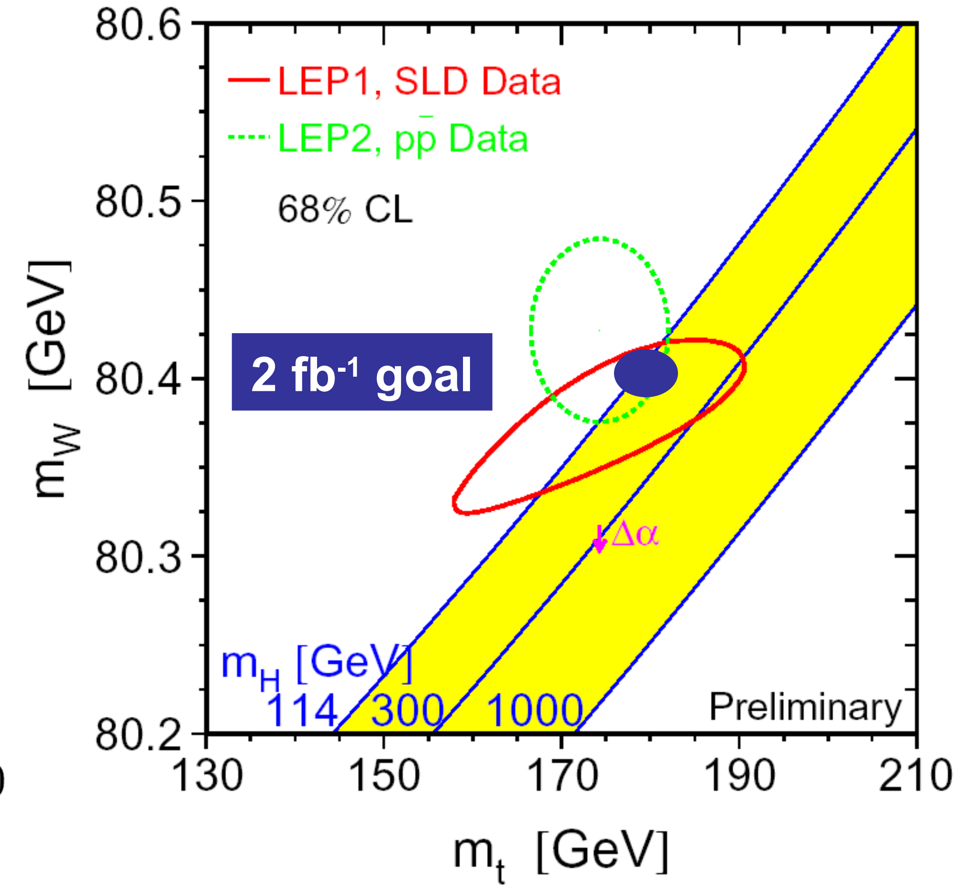


Best Run II top mass measurement from CDF ℓ+jets (L=162pb^{-1}) using dynamic likelihood:

$$m_t = 177.8^{+4.5}_{-5.0}(stat) \pm 6.2(syst) GeV/c^2$$

Electroweak fits





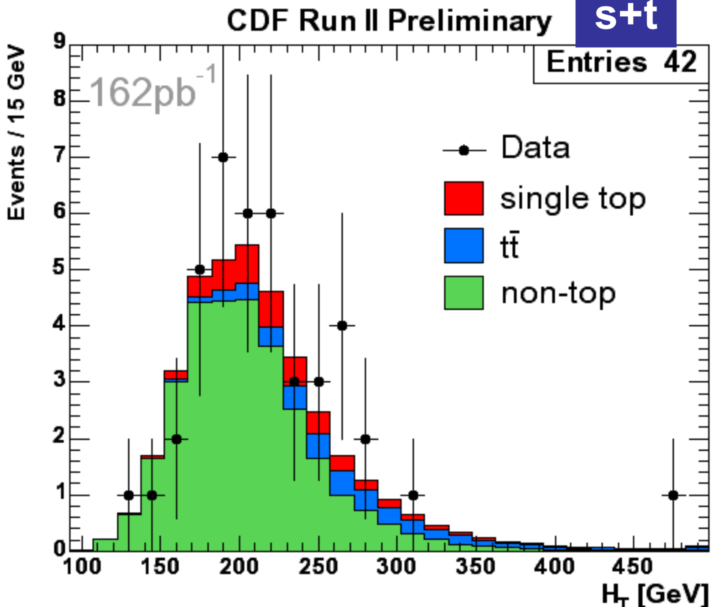
New most likely value: $m_H = 117^{+67}_{-45}$ GeV or $m_H < 251$ GeV (95% C.L.)

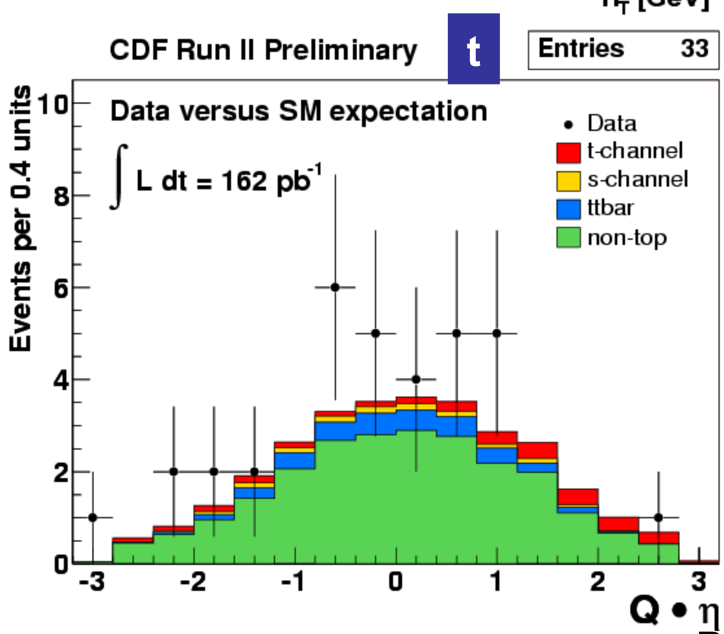
Excluded with direct searches at LEP2: $m_H > 114.4$ GeV (95% C.L.)

Tevatron goal with 2 fb^{-1} measure m_t to ±3 GeV and m_W to ±15 MeV

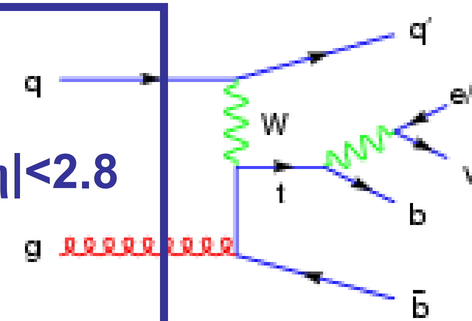
Single top search

hep-ex/0410058





1 Lepton p_T>20 GeV
MET>20 GeV
Exactly 2 jets E_T>15 GeV |η|<2.8
≥ 1 b-tag
M_{lvb} [140,210] GeV



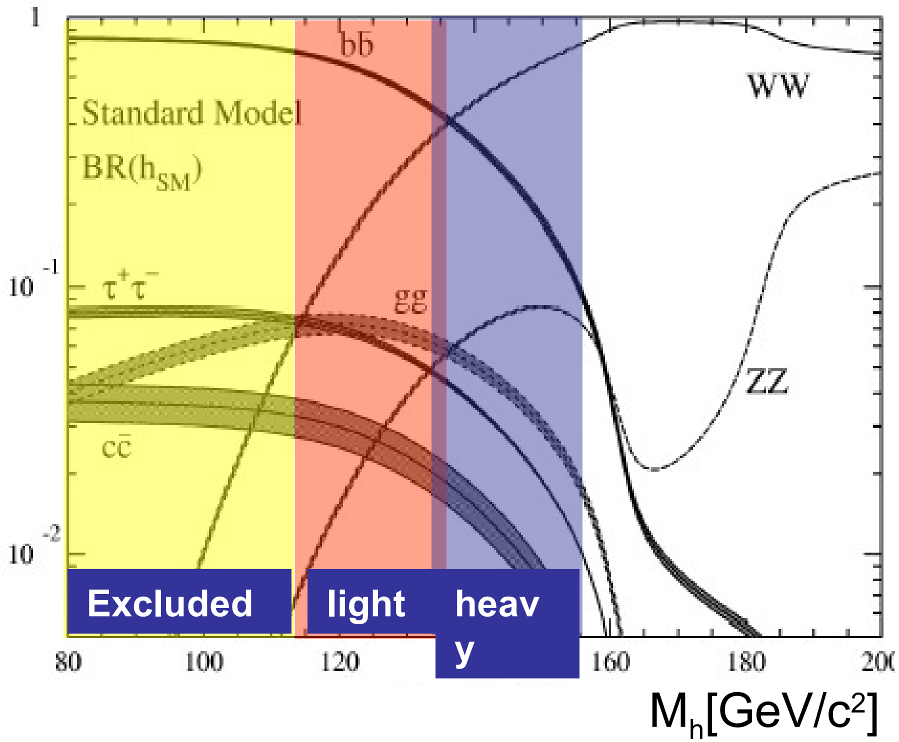
Maximum likelihood fit to data H_T or Q•η distributions using a sum of templates determined from MC: single top (MadEvent), tt (PYTHIA), non-top: Wbb (ALPGEN)

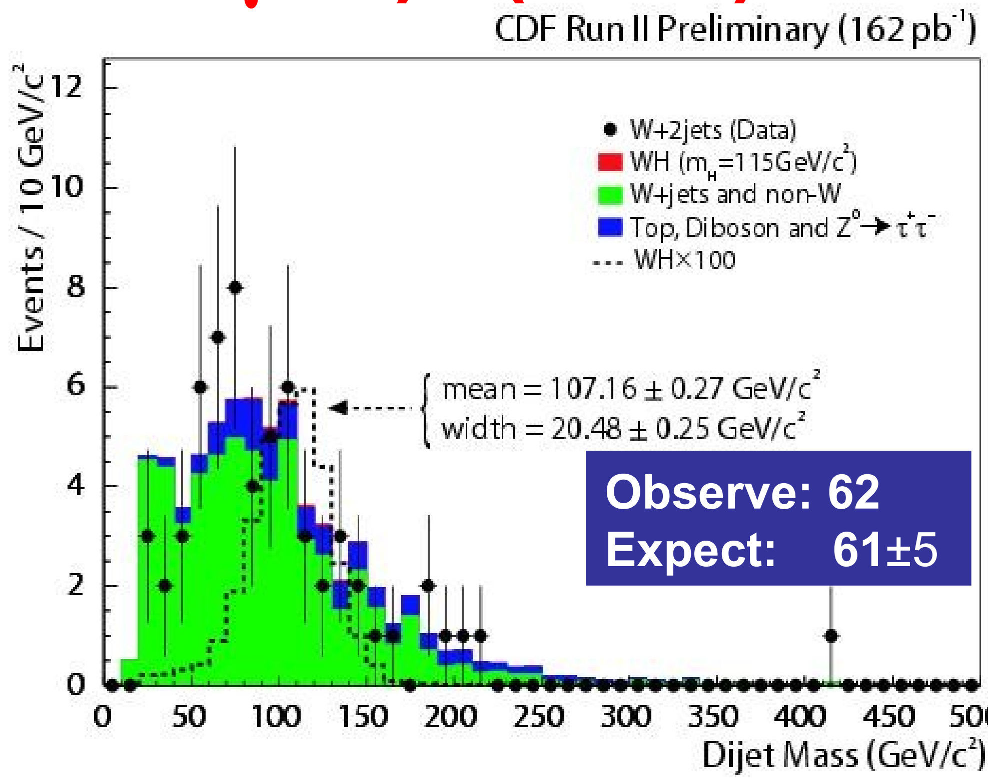
Background allowed to float but constrained to expectation.

95% C.L. limits Observed (Expected)

Channel	CDF (pb)	DØ (pb)
s+t	<17.8 (13.6)	<23 (20)
t	<10.1 (11.2)	<25 (23)
s	<13.6 (12.1)	<19 (16)

Light Higgs: W(→eν /μ ν)H(→bb)





Simulations performed with Alpgen + Herwig and detailed detector response

Main backgrounds:

- Mistags, Wbb, Wcc, QCD, tt, single top

CDF Run II limit: σ (WH→ℓν bb) < 5 pb

Exceeds CDF's Run I limit: σ < 14 pb

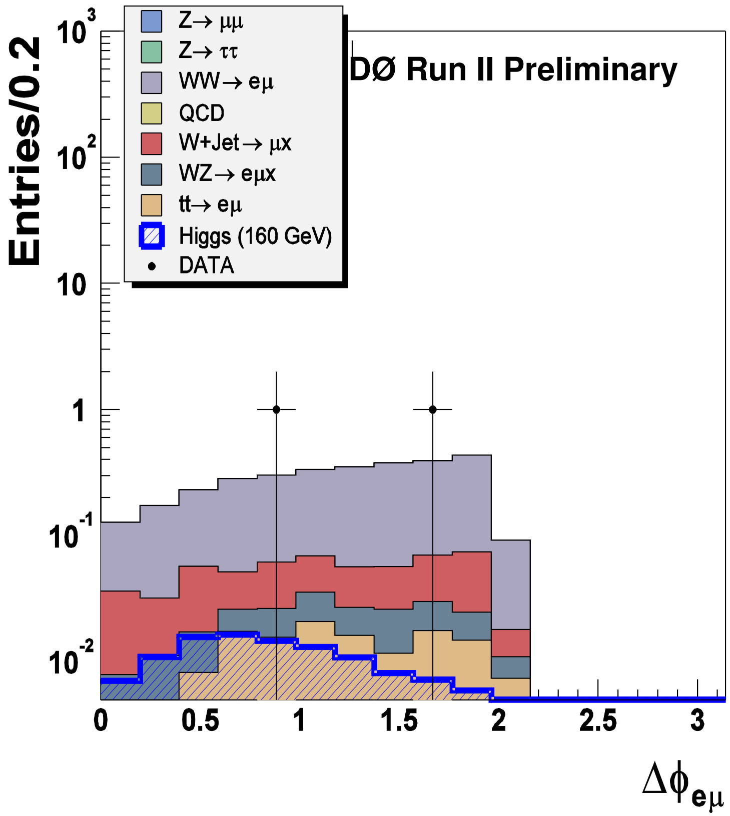
Heavy Higgs: $H \to WW^{(*)} \to \ell^+\ell^-\nu\nu$

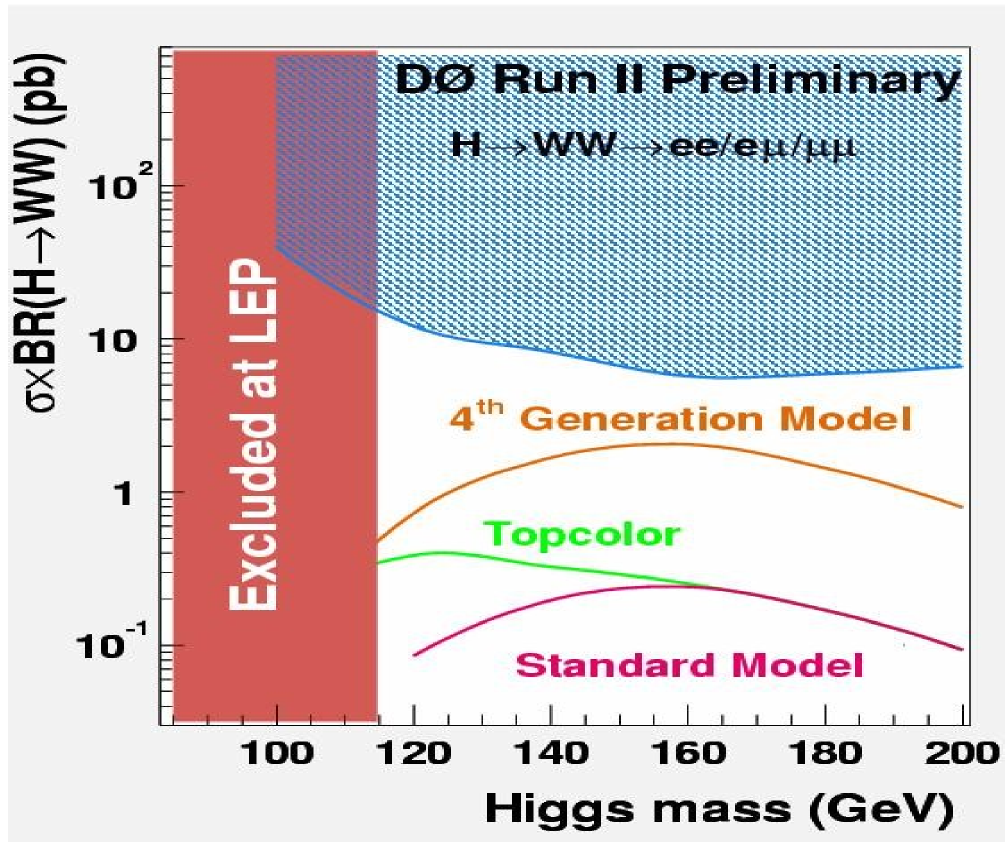
	ee	eμ	μμ
Observed	2	2	5
Expected	2.7±0.4	3.1±0.3	5.3±0.6

Cannot reconstruct H mass

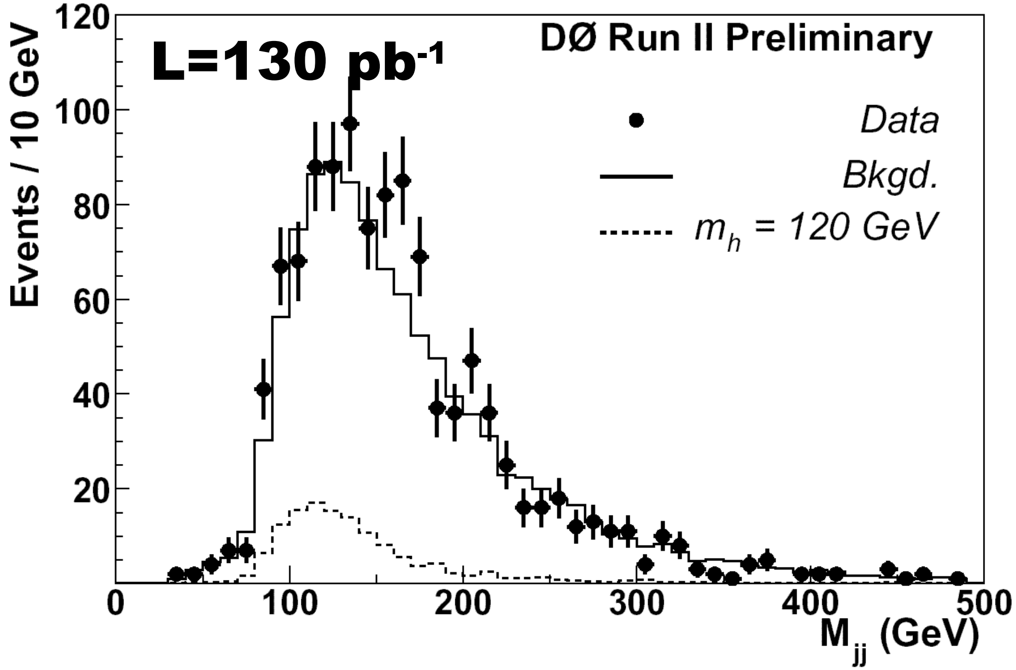
Use spin correlations to suppress bkg

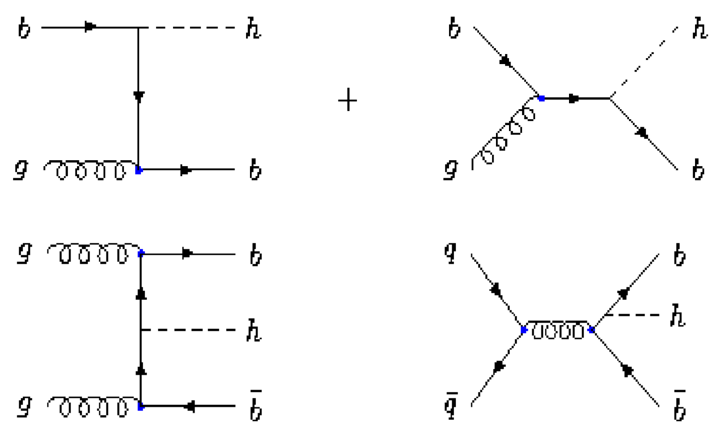
Good agreement in all final states

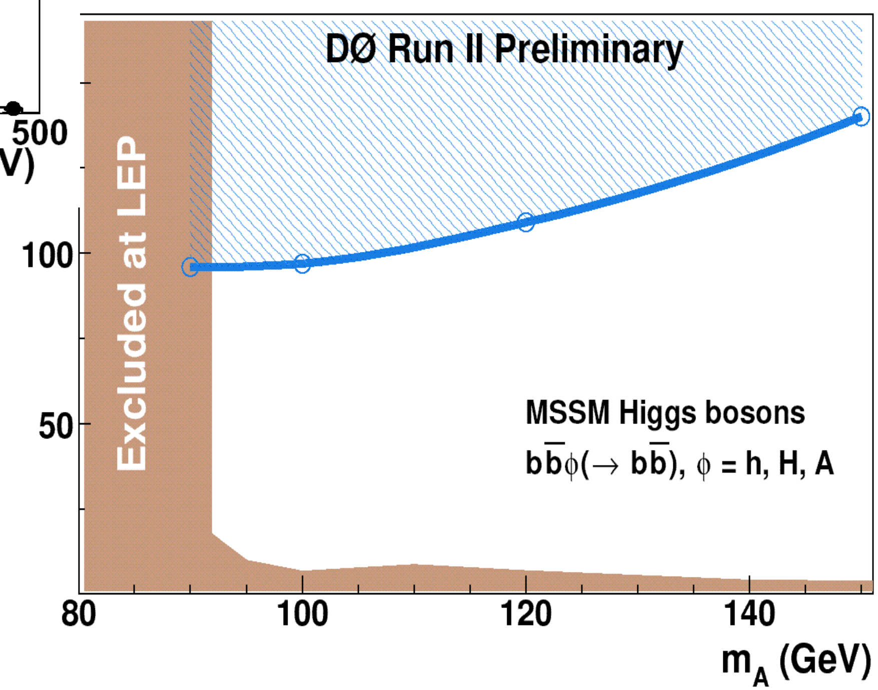




Light SUSY Higgs at high tanβ

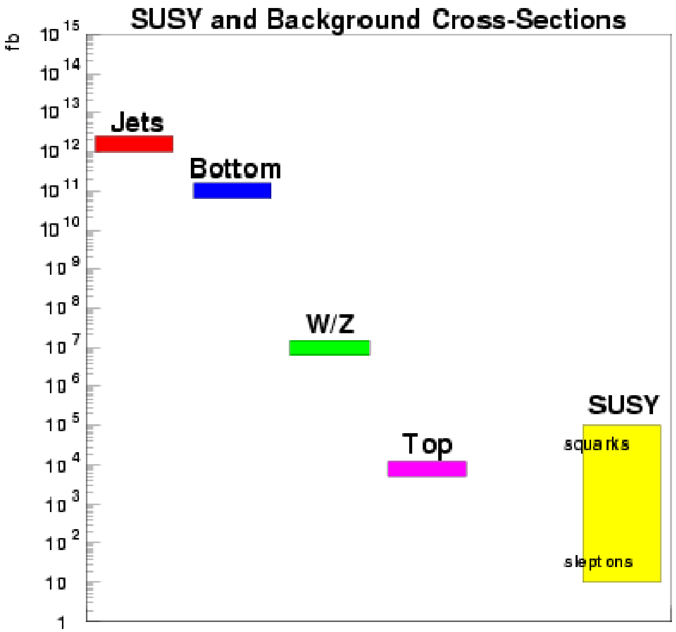


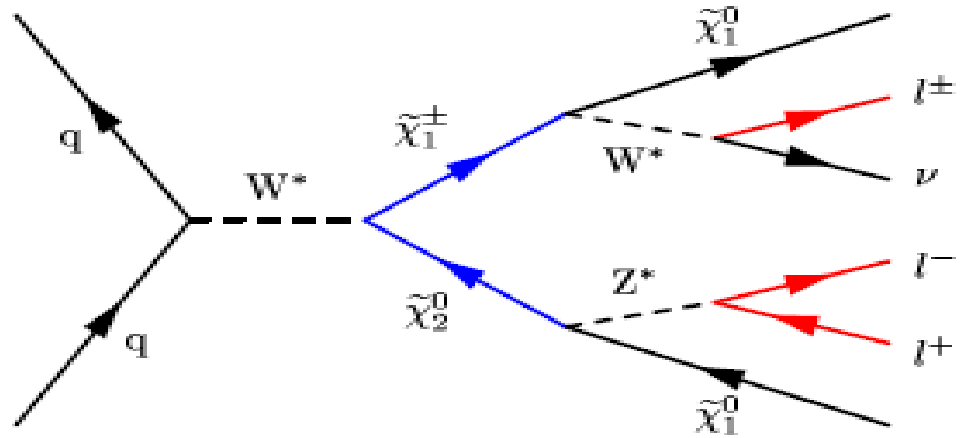




- Require at least 3 jets with ≥3 b-tags
- Look for mass resonance in M_{jj}
- Backround shape determined from data
- Will reach tanβ~40 at m_A=100 with 1.6 fb^{-1}
- PRL with updated 230pb^{-1} in coll. review

mSUGRA searches: trileptons

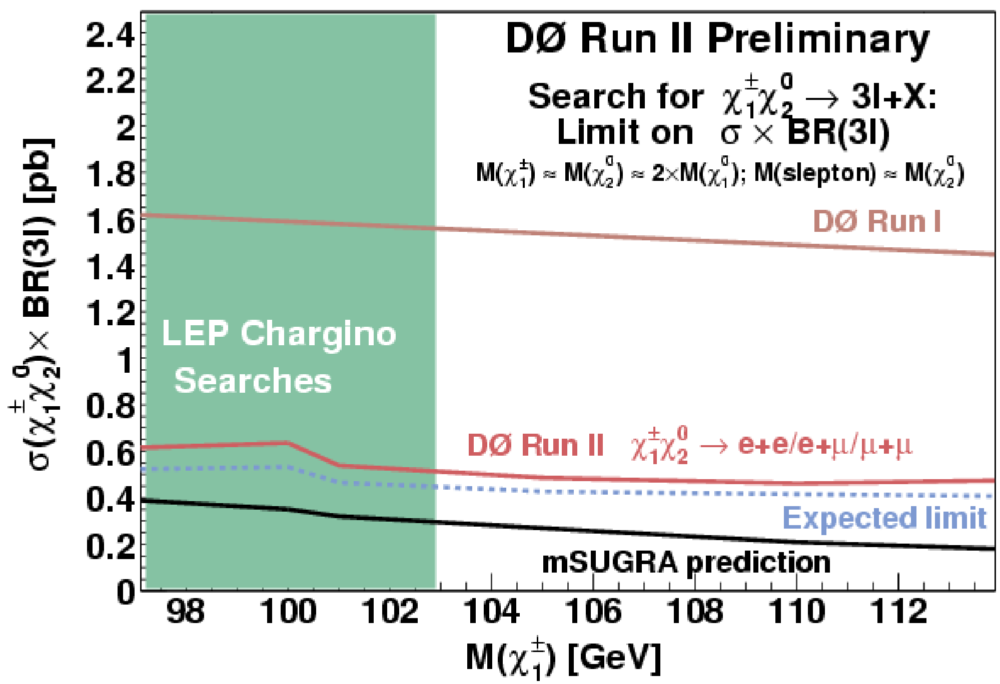




Clean signature, but low σ

Low SM bkg

L=158pb^{-1}	ee+ℓ	eμ+ℓ	μμ+ℓ
Observed	1	0	1
Expected	0.27	0.54	0.23



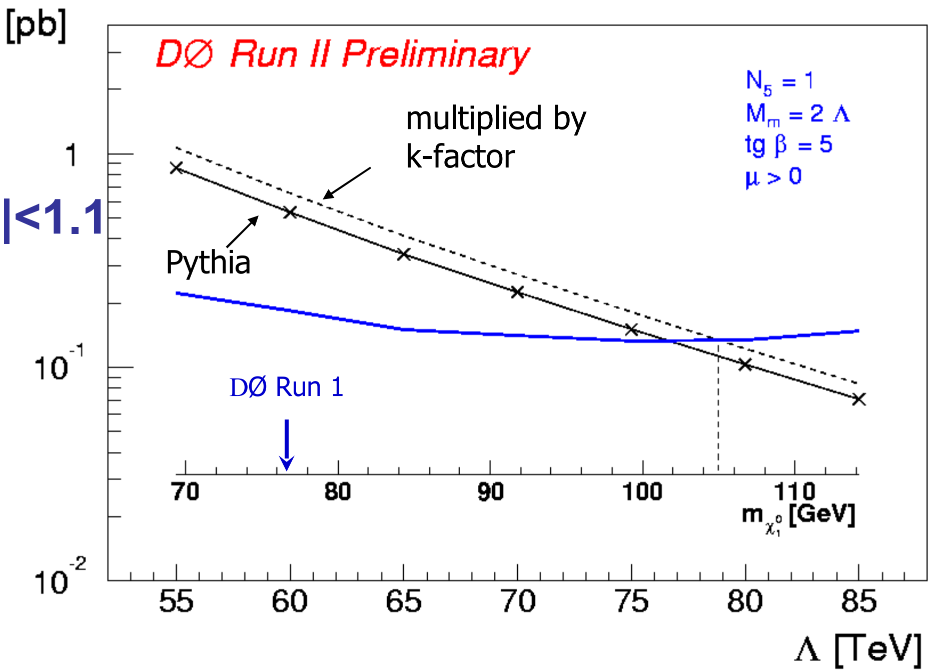
Gauge Mediated SUSY breaking

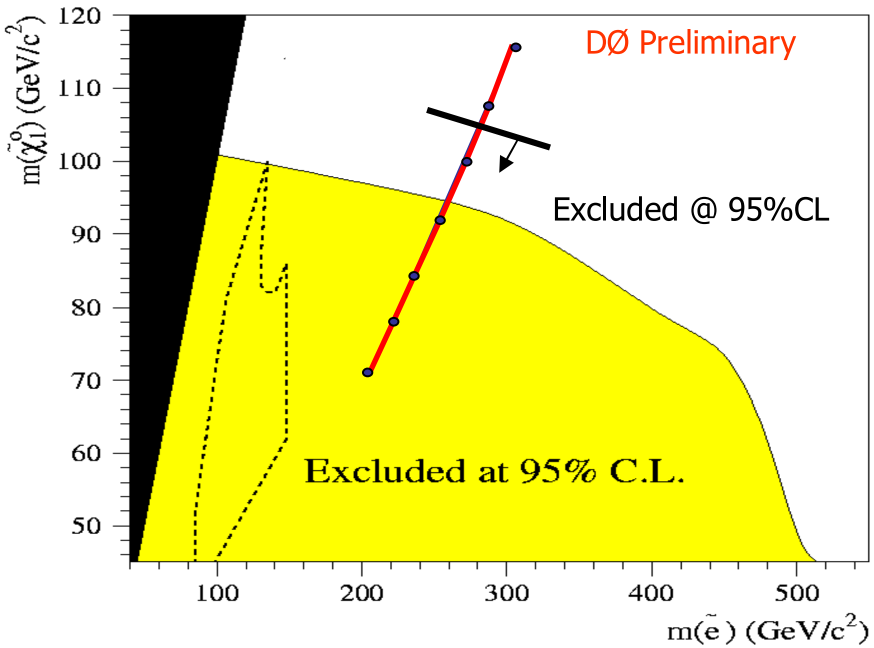
Gravitino LSP, neutralino NLSP:

$$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$$

- ►Two photons with $p_T(\gamma)$>20GeV in $|\eta|$<1.1
- ► Missing E_T > 40 GeV
- ► MET separated from jets

Observed 1 event
expected 2.5 SM events





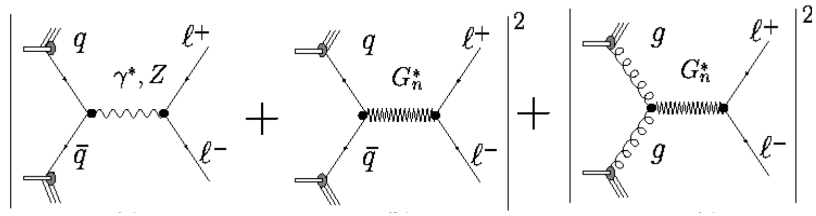
Λ > 78.7 TeV

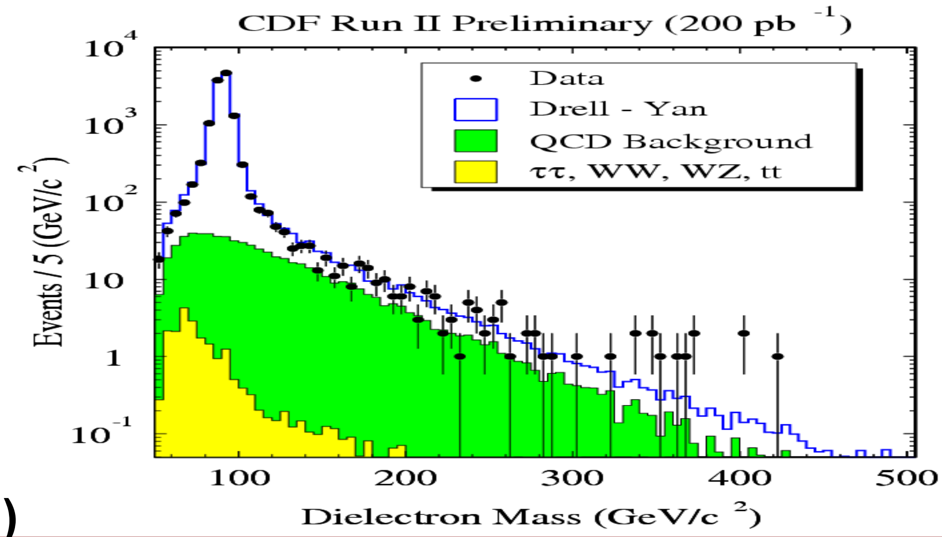
$m(\chi_1^0)$> 105 GeV

$m(\chi_1^+)$> 180 GeV

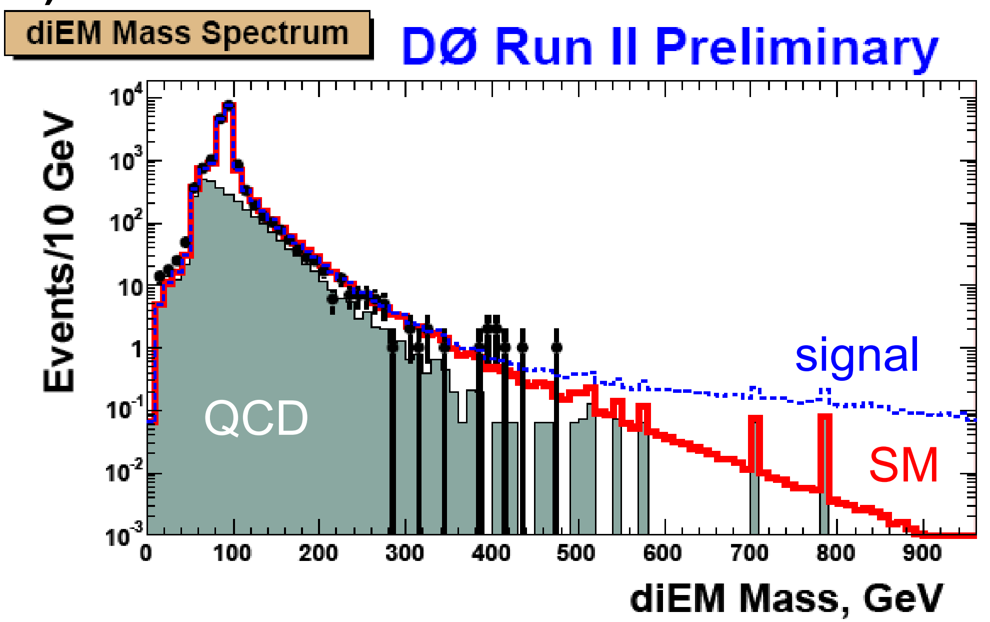
Improves LEP limit for this model

Large extra dimensions





Signature: dileptons or diphotons (also for Z', SUSY RPV, techincolor…)
No deviations are observed



CDF Run II $M_S > 1.11$ **TeV**

DØ Run II $M_S > 1.36$ **TeV**

(M_S is (3+n)-dimensional Plank scale)


First Meeting 16 - 18 Sept. '04 Fermilab • Midterm meetings at Brookhaven & CERN • Final meeting at Fermilab, Fall '05
TeV4LHC WORKSHOP
Using the data & experience from the Tevatron to prepare for the LHC
TeV4LHC Organizing Committee:
Georges Azuelos (U. Montreal)
Ulrich Baur (SUNY at Buffalo)
Marcela Carena, Chair (FNAL)
Sally Dawson (BNL)
Dan Green (FNAL)
Ian Hinchliffe (LBL)
Young-Kee Kim (U. Chicago)
Joe Lykken (FNAL)
Stephen Mrenna (FNAL)
Heidi Schellman (Northwestern)
John Womersley (FNAL)
Working Groups
QCD, Top & Electroweak Physics,
Higgs, and Physics Landscape.
Contacts: Cynthia M. Sazama (FNAL)
sazama@fnal.gov • tev4lhc-org@fnal.gov
Information & Registration: http://conferences.fnal.gov/tev4lhc/

TeV4LHC Workshop

The purpose: Use Tevatron data and experience to prepare for the LHC
Identify areas where further theoretical work is needed

Tevatron → LHC

- ***Improved event modelling and theoretical understanding of cross sections for signals and backgrounds***
- ***Experience with real data***

LHC → Tevatron

- ***Determine where current LHC prospects are strongly dependent on simulations/extrapolations***
- ***Identify difficult analyses at LHC to investigate them at the Tevatron***

The Workshop will combine Talks and Working Sessions, with the idea of initiating specific projects in these areas . Connect TeVatron and LHC people to work on these projects.

- **The 1st meeting was held at Fermilab, 16-18 September, 2004.**
- **The NEXT MEETING will be held at Brookhaven National Lab., 3-5 February, 2005: www.bnl.gov/tev4lhc**
- **A follow-up meeting will be held at CERN, in late April, 2005**
- **The final meeting will be held at FNAL, in the Fall, 2005**
- **Would have liked to have more participation from LHC people**

TeV4LHC Workshop

- From Regina Demina (Rochester) in "Challenges of hadron colliders":
- Why did it take the TeV almost three years (March 2001-December 2003) to publish the first paper?
- She asked some Run II physics conveners from CDF and DØ:

  What were the limiting factors?
- There was no clear leading limitation but rather several limiting factors:

1. Detector (and accelerator) performance:
   - Calorimeter calibration (in both experiments)
   - Alignment (tracker and calorimeter)
   - Luminosity delivered by the Tevatron (was too low,… now too high?)
   - Tracking and muons: no major complains both worked fine
2. Maturity of reconstruction algorithms
3. Complexity of the software and reliability of the MC (availability of samples)
4. CPU, speed and ease of data access, data format
5. Social issues and politics

TeV4LHC Workshop: Conclusions

- Lessons of commissioning from Run II:

  4 months of CDF Si cabling WHILE taking physics data

  Premature emphasis on physics was counterproductive: it’s hard to commission the detector while taking physics data.
- Common final states should share ID’s and background calculations!
- Build common tools for the physicist (Luminosity calculation, trigger turn on curves, etc.)
- Big complaint: Lack of involvement from senior people
- Too high standards, perfectionism! (Run I, LEP)

- LHC has probably avoided many mistakes made at the Tevatron
- But many others are general and will be worse at the LHC
- This will affect LHC’s ability to do physics
- Tevatron people can give valuable input!
- We all need the LHC to be a success!!

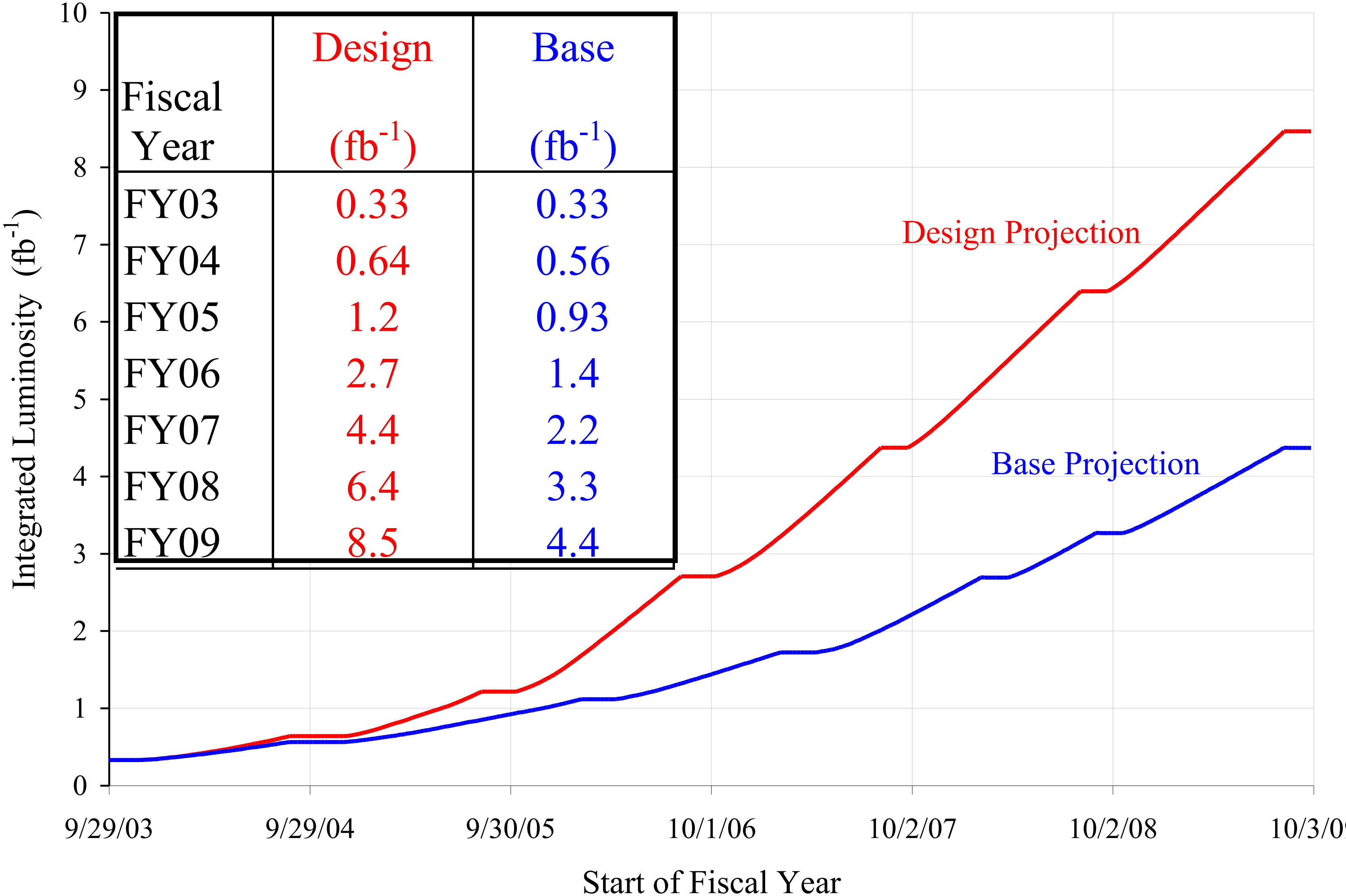
Conclusions

- ►The Tevatron Run II is progressing well
- ►CDF and DØ are collecting data efficiently ~ x5 Run I
- ►Providing the physics results they were designed for
- ►30 published/submitted papers with Run II data
- ►Electroweak measurements provide ideal scenario to test the SM and are fundamental to understand the detectors
- ►Increased $\sqrt{s}$ at Run II allows testing of higher Q^2
- ►Extensive top-quark studies
- ►Understanding of backgrounds for Higgs searches is improving, new better limits
- ►Searches limits have now surpassed Run I sensitivity

Conclusions

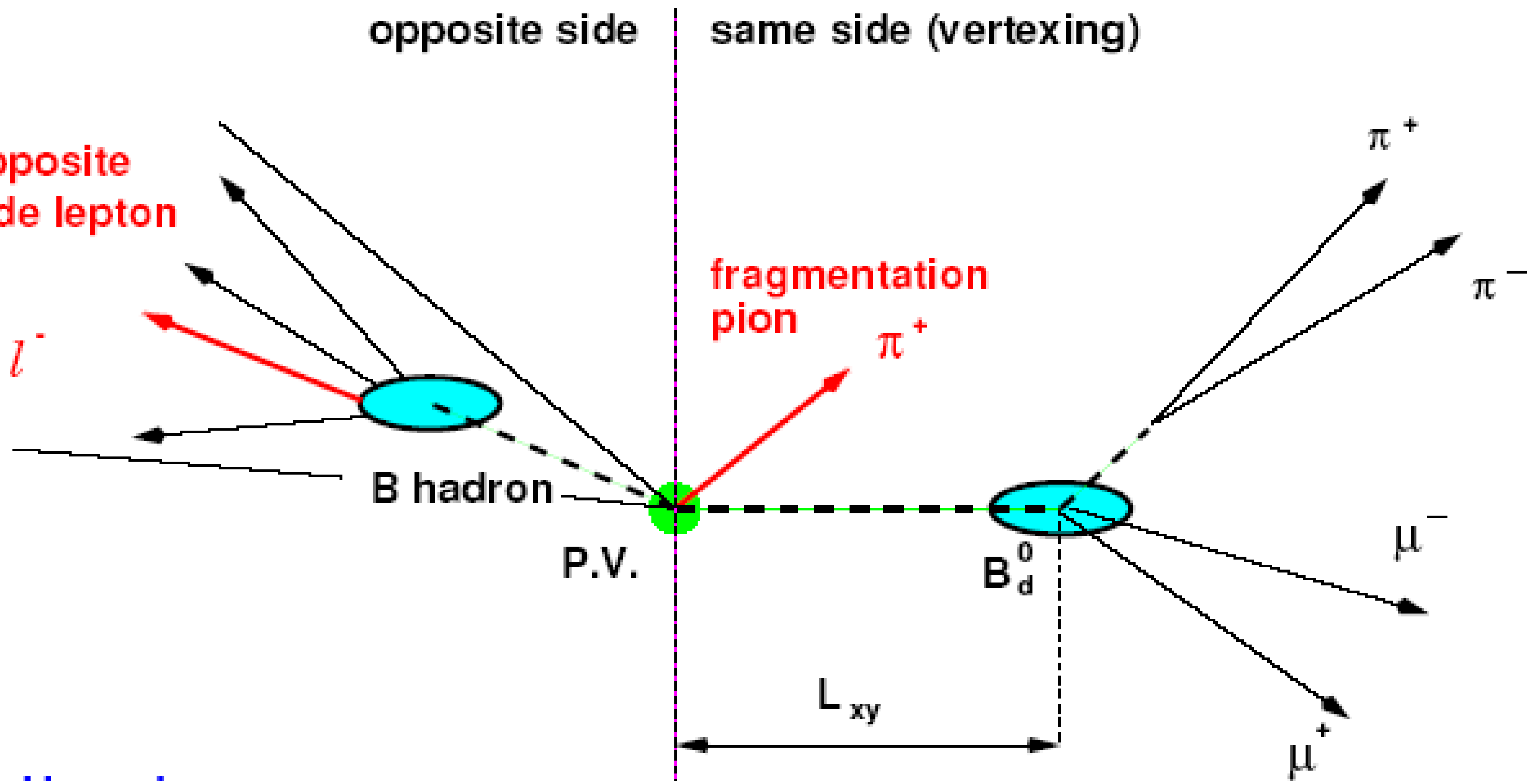
- There is a lot of physics at the Tevatron
  - Will go strong with 2-4 fb^{-1} of data before LHC turn on.
  - Understand now what to measure at TeV to make LHC simpler
- Lots of potential lessons
  - Tevatron also messy environment
  - Large collaboration with significant European contributions
  - Object ID, Algorithms, Data formats, Remote Computing…
- Lots of experience in a hadron - hadron environment
  - We should have even more at a high luminosity by the time the LHC turns on!

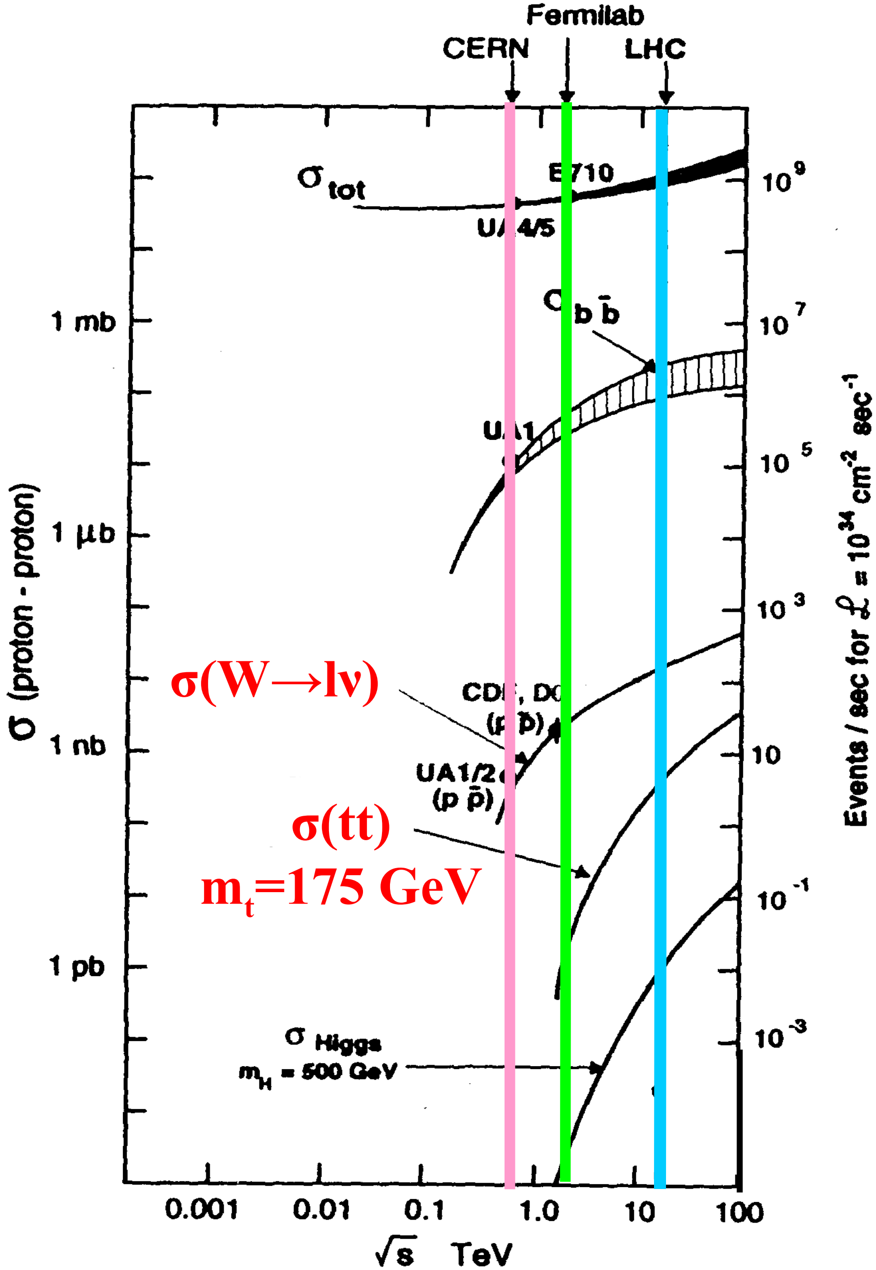
Run II luminosity prospects



Fiscal Year	Design (fb^{-1})	Base (fb^{-1})
FY03	0.33	0.33
FY04	0.64	0.56
FY05	1.2	0.93
FY06	2.7	1.4
FY07	4.4	2.2
FY08	6.4	3.3
FY09	8.5	4.4

Extra: Initial B-flavor tagging





Triggering

Collision rate is huge:

- ►Every 396ns at the Tevatron
- ►Every 25ns at the LHC

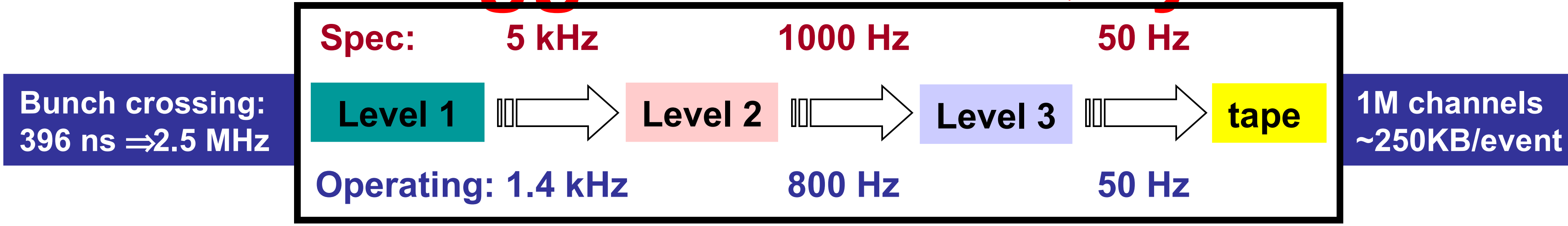
Total cross section is also big ~0.1b

- ►2-3 interactions per collision at $L=10^{32}$
- ►20 interactions per collision at $L=10^{34}$

W, Z, top, H are relatively rare

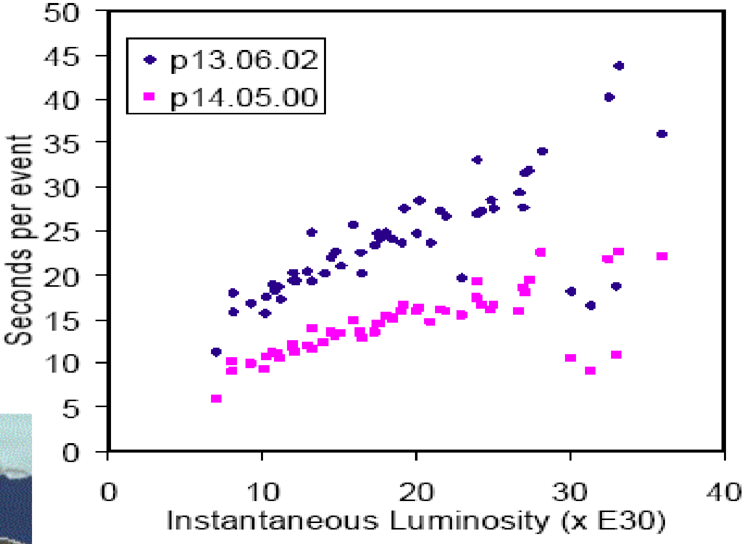
Trigger and Luminosity are crucial

DØ Trigger and DAQ system



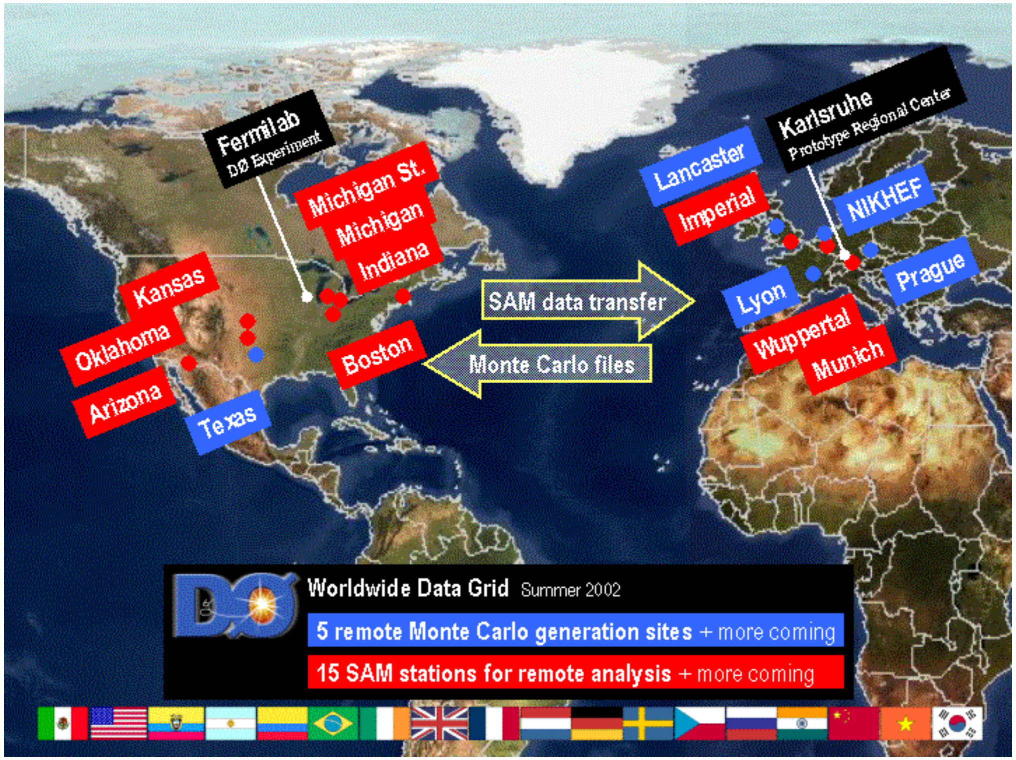
- **Runs comfortably up to $5x10^{31}$ $cm^{-2}s^{-1}$ and will keep pace with luminosity growth as tracking triggers completed, CPUs added.**
- **L1: >100 independent trigger bits**
  - **Fast trigger pick-offs from all detectors**
  - **Custom hardware/firmware**
  - **Trigger on hit patters in individual detector elements**
- **L2: Combine Level 1 regions and objects**
  - **Input rate expansion w/ processor replacements**
- **L3: Full detector readout**
  - **Extensive suite of filters available**
- **DAQ: VME-based PCs and Ethernet switches**
  - **Working to reduce Front End Busy rate (~4%, mostly tracking)**
  - **Event reconstruction: Linux commodity farm to make L3 decision**
  - **Can monitor from a cell phone!**
  - **Upgrade: Extra 50 Hz to tape**
  - **Possibly: another extra 50 Hz (for a total of 150Hz) of B physics triggers**

DØ Offline event reconstruction and analysis



DØ Reconstruction Farm

- 240 1.8 GHz dual CPU machines
- 20M event/week capacity
- events processed within days of collection
- 1G events processed in Run II so far



Globally Distributed Resources

11 remote Monte Carlo Farms

- Running full GEANT, DØ reconstruction and trigger simulation

40 SAM stations for remote analysis

- Over 2Pb moved last year
- Up to 200Tb/month