Top Quark Physics at D0

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Particle Physics Seminar at

BROOKHAVEN
NATIONAL LABORATORY

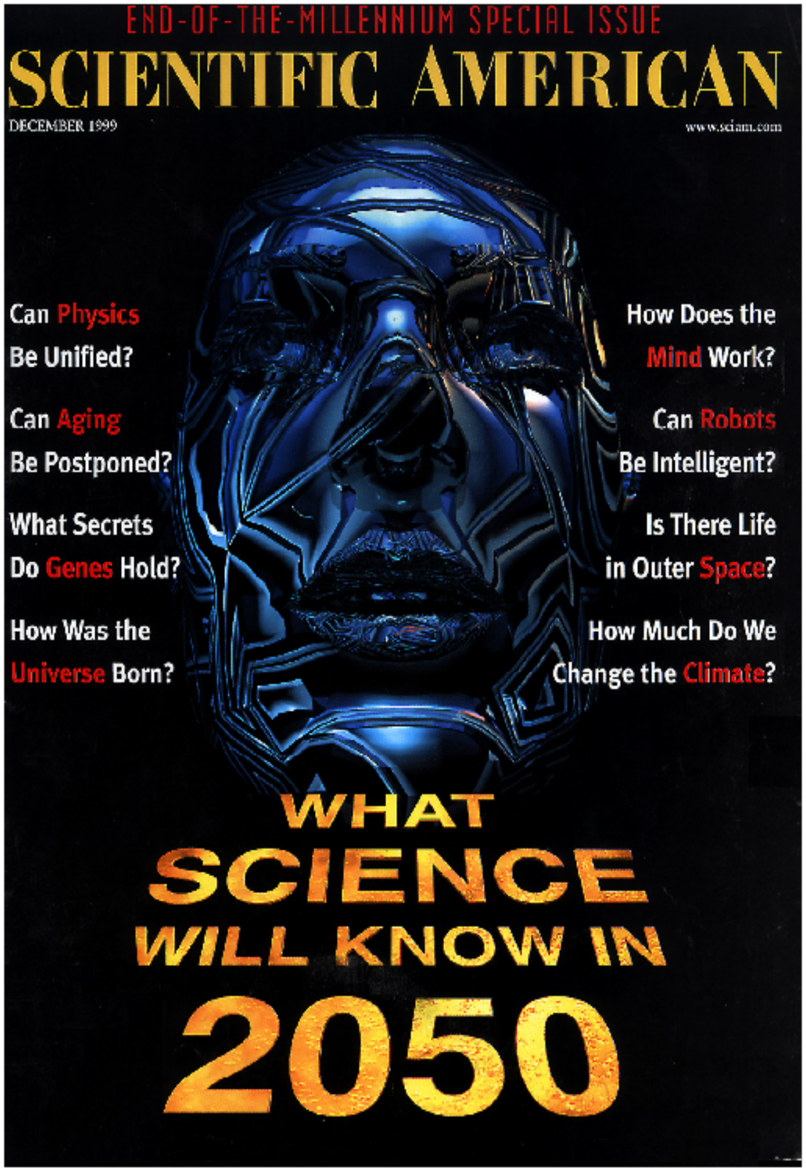
26 May 2011

Can Physics
Be Unified ?

Can Aging
Be Postponed ?

What Secrets
Do Genes Hold ?

How Was the
Universe Born ?



How Does the
Mind Work ?

Can Robots
Be Intelligent ?

Is There Life
In Outer Space?

How Much Do We
Change the Climate?

Big Questions

Can we combine QM and G. Relativity?

Dark energy?
Cosmological constant?

Unification of forces?

Arrow of time

Correct interpretation of QM?

Dark matter?

Where is antimatter?

Black hole information paradox?

Why three generations of matter?

Extra dimensions?

Magnetic monopoles?

Inflation?

Are there many universes?

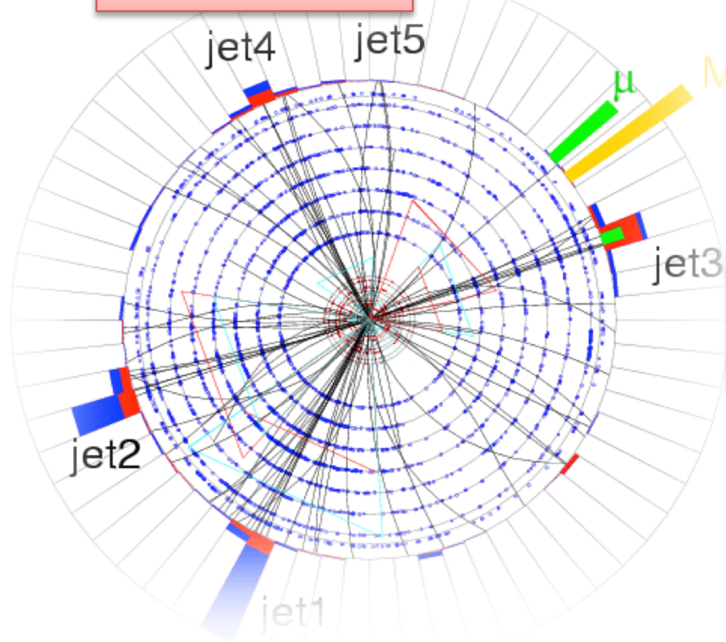
Mechanism of symmetry breaking, Higgs, origin of mass, mecanism for meutrino masses?

End of universe?

Locality in QM (Quantum entanglement)?

Clues from P-P(Pbar) Collisions?

- Unification of forces?
- Dark matter?
- Where is antimatter?
- Can we combine QM and G. Relativity?
- Arrow of time
- Higgs



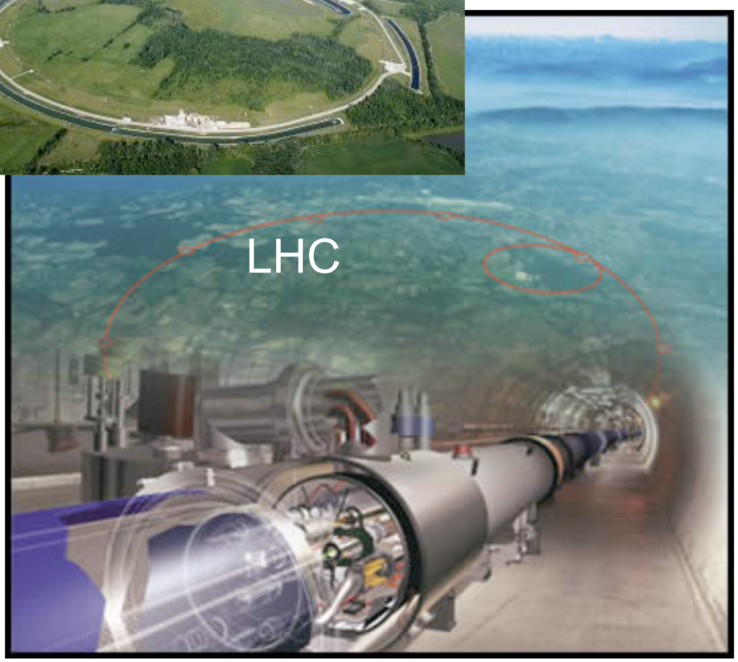
- Correct interpretation of QM?
- Why three generations of matter?
- Mechanism of symmetry breaking, origin of mass
- Extra dimensions?

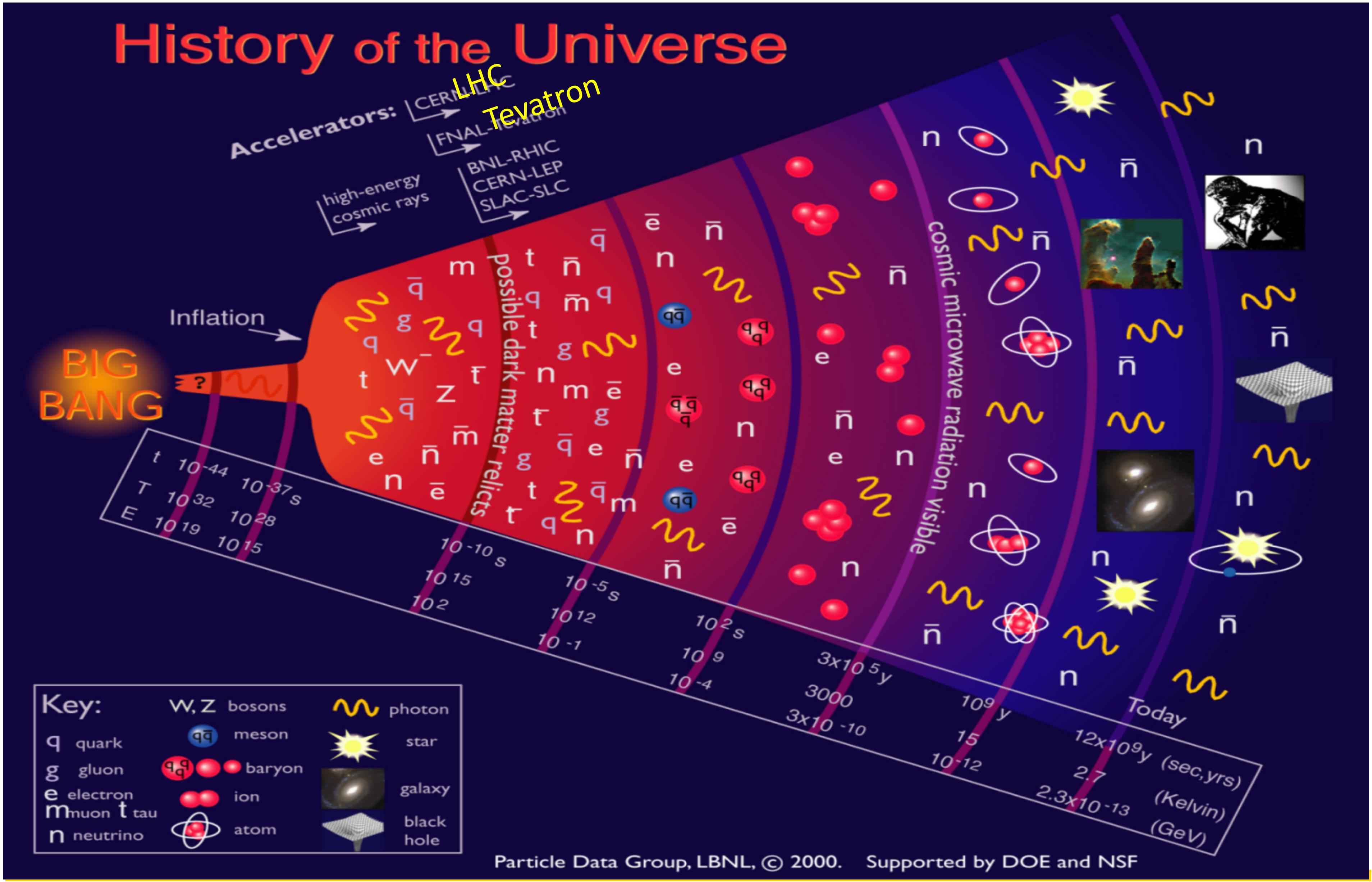
QCD	B Physics	Electroweak	Top Quark	Higgs	New Phenomenon

Chicago and Geneva

©1994 Magellan Geographix^{SM}Santa Barbara, CA (800) 929-4MAP Robinson Projection

Theorists and experimentalist have been busy for the last couple of decades




History of the Universe
Accelerators:
CERN-LHC
LHC
FNAL-Tevatron
Tevatron
BNL-RHIC
CERN-LEP
SLAC-SLC
high-energy cosmic rays
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
t 10-44 10-37 s
T 10 32 10 28
E 10 19 10 15
10 -10 s
10 15
10 2
10 -5 s
10 12
10 -1
10 2 s
10 9
10 -4
3x10 5 y
3000
3x10 -10
10 9 y
15
10 -12
Today
12x10 9 y (sec,yrs)
2.7 (Kelvin)
2.3x10 -13 (GeV)
Key:
q quark
g gluon
e electron
m muon
t tau
n neutrino
W, Z bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
Particle Data Group, LBNL, © 2000. Supported by DOE and NSF

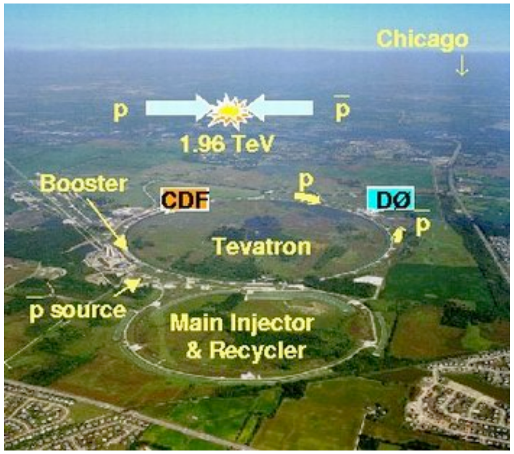
Tevatron

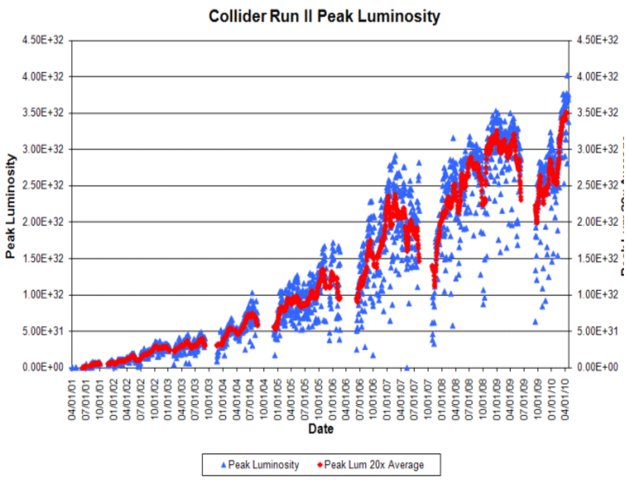
25years ago, first Tevatron collisions in 1985

Tevatron expected luminosity ~ $3x10^{30}$ $cm^{-2}s^{-1}$

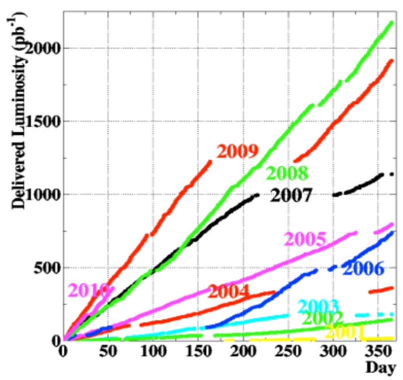
Now running at $3x10^{32}$ $cm^{-2}s^{-1}$ almost routinely !

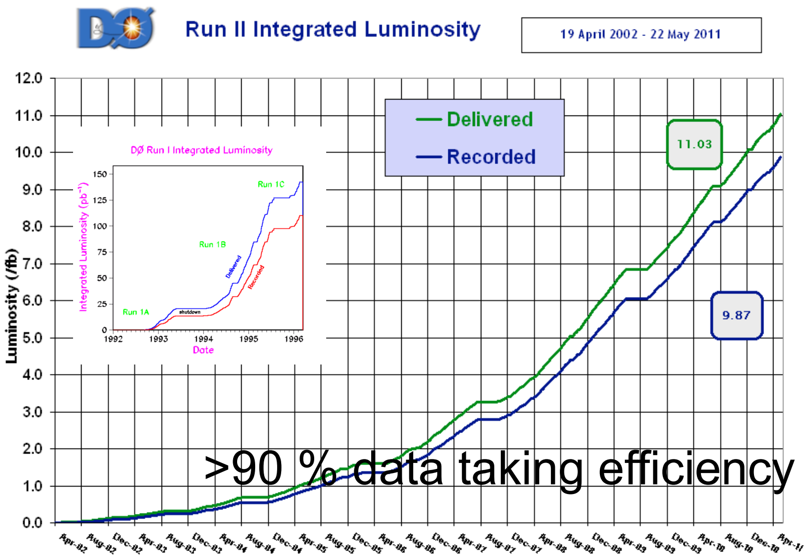
…and this is not the only time when a Tevatron team exceeded its own expectations and projections





Luminosity Delivered per Calendar Year (*CDF Exp*)

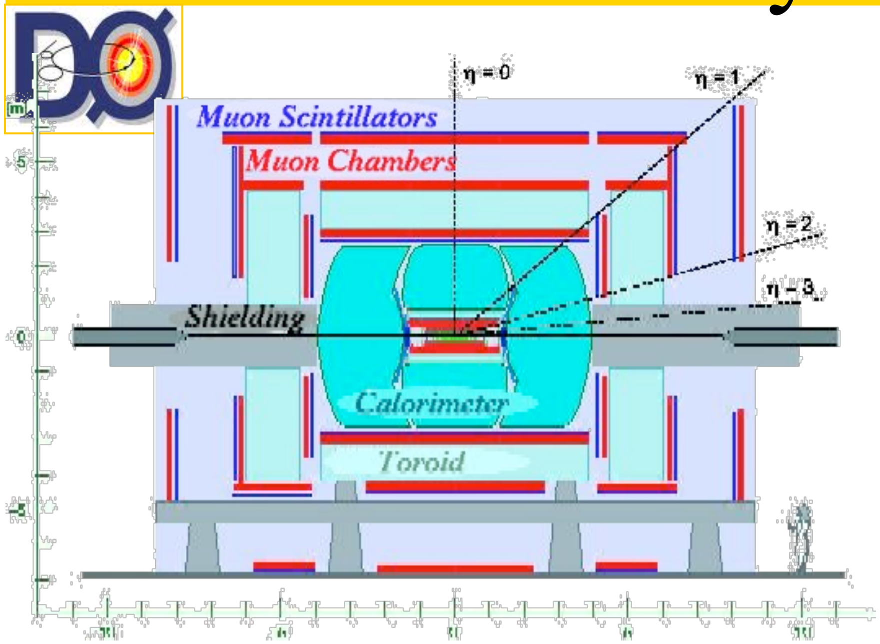




>90 % data taking efficiency

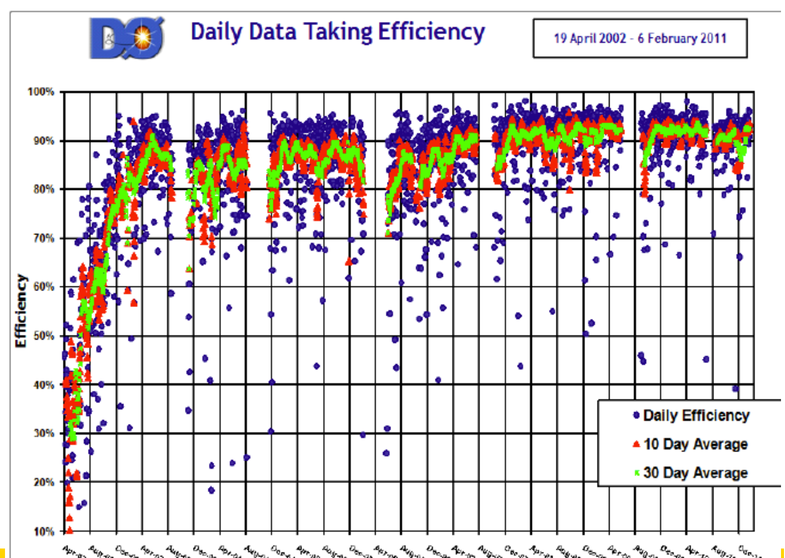
For 25 years, the Tevatron has been the only machine at the frontier… and we have learned much.

Our Eyes - Detectors



Institutions: 86 total, 37 US, 49 non-US

- D0: weighs 5000 tons, is about 12 meters in all three dimensions.
- All purpos detector
  - Good resolution for track momenta, vertex, calorimeter
  - ~90% avg. data taking effeiciency

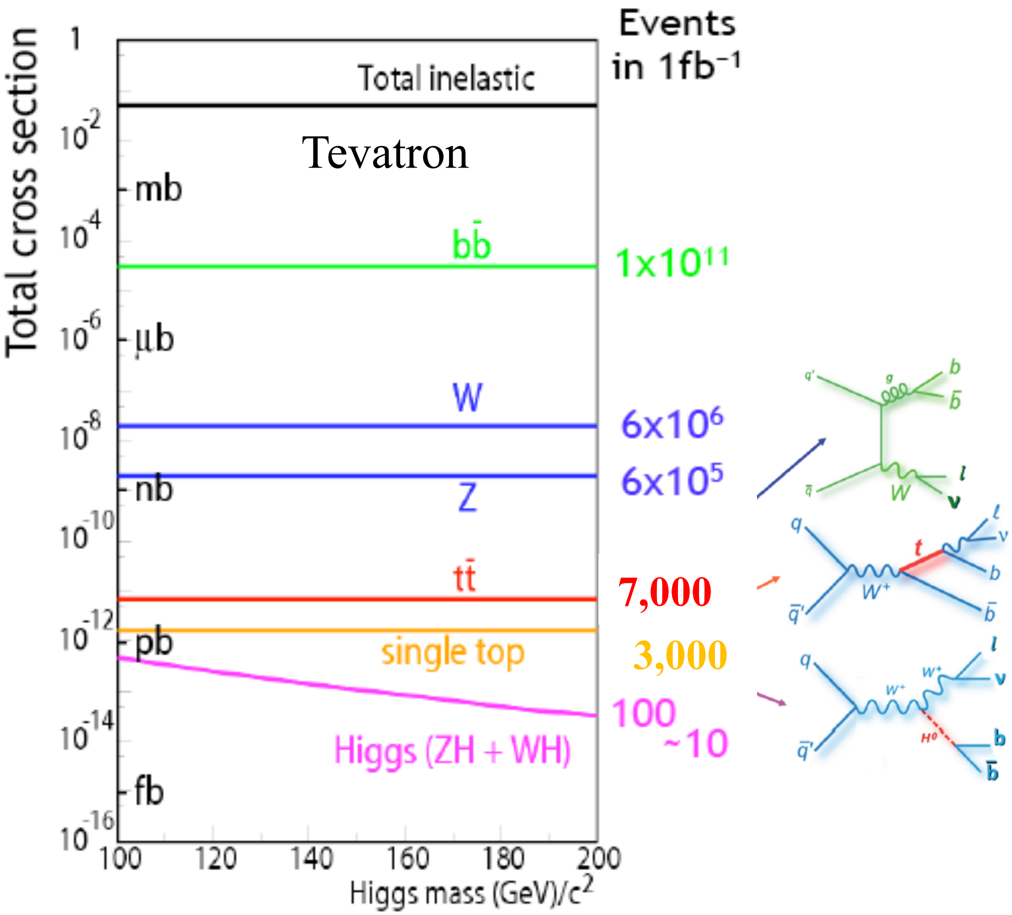


Production of Fundamental Particles

- Cross section:
  Total inelastic cross section is huge
  ~60 trillion events in 1 fb^{-1}
  ~ 2 MHz interaction rate

- Translate it into rates
  bb: 42 kHz
  Jets with ET>40 GeV: 300 Hz
  W: 3 Hz
  Top: 2-3 eventst /hour

- Trigger needs to select the interesting



The key is trigger – that is rejecting as much as we can while keeping as many interesting events as possible on tape

Why Look at The Top Quark?

- **Was discovered at Fermilab in1995**
- The heaviest known fundamental particle
  - m_t = 173.3 ±1.1 GeV (<1% precision)

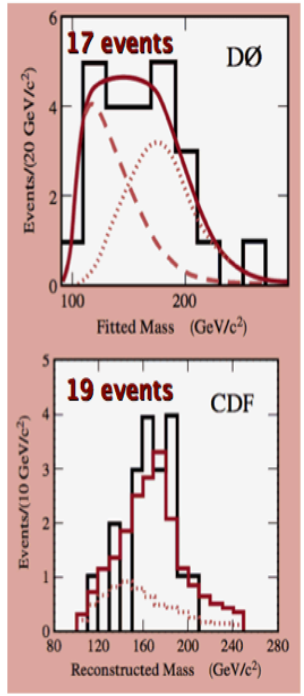
    Close to a gold atom

  τ = 5×10^{-25} s <<Λ_{QCD}^{-1}

  Decays before hadronization
- Mass close to scale of electroweak symmetry breaking
  - Only quark for which coupling to Higgs is significant
  - May shed light on EWSB mechanism
- Top quark plays special role in many of the new physics models

discovery

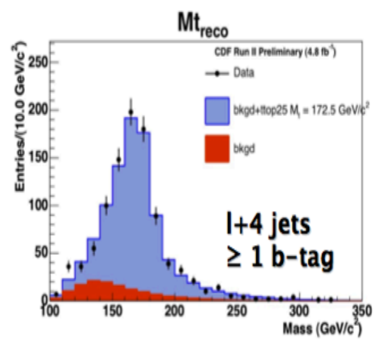
PRL 74, 2632 (1995)
PRL 74, 2626 (1995)



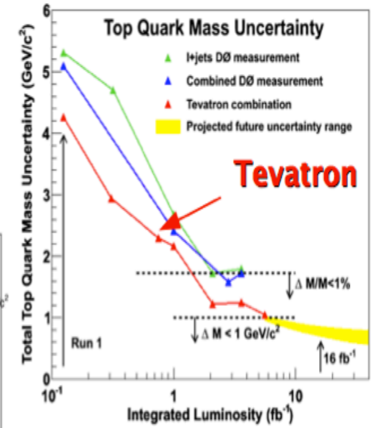
1995, CDF and DØ experiments, Fermilab

today

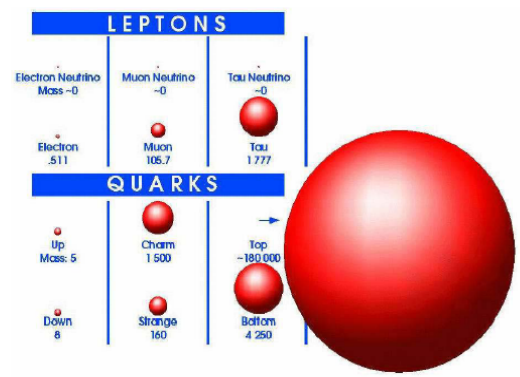
~1000 events



precision

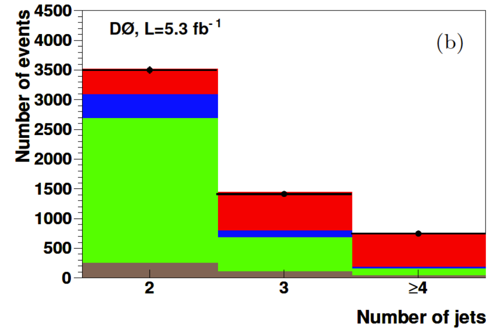


searches



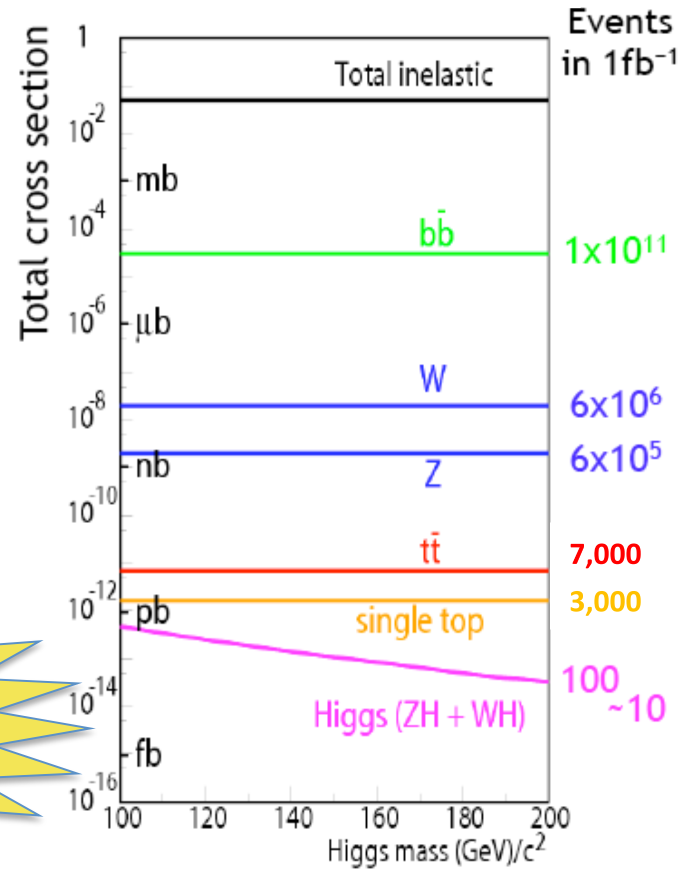
Why Keep Looking at the Top?

- Even more than a decade after its discovery, our sample consists of ~ 1000 top quark events
  - Many of the measurements of top quark properties are still statistics limited



Lot of room for surprises!

Are recent excess hint of something?

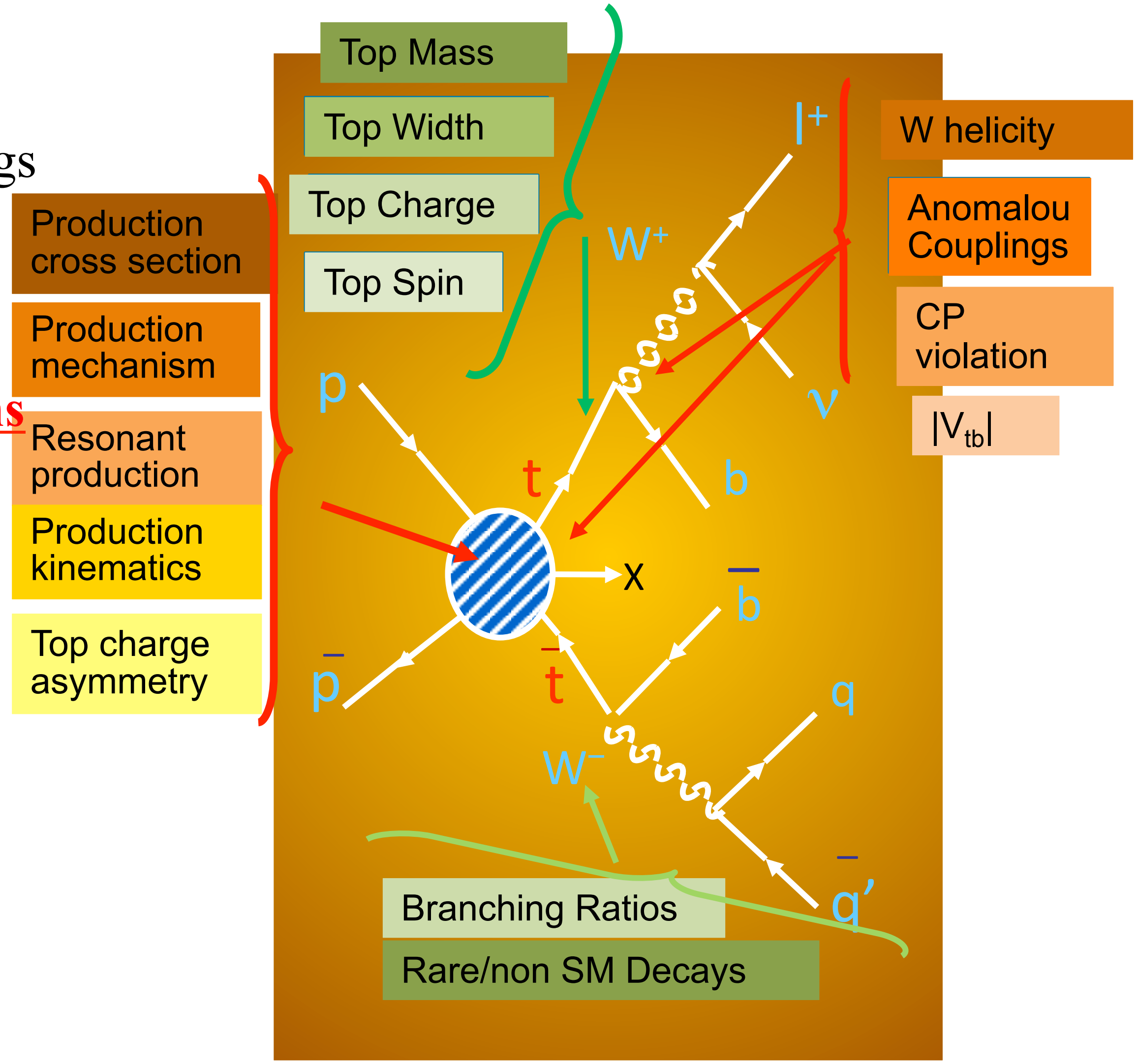


Why we Love to Talk About Top?

- Top quark is the heaviest known elementary particle
- Strongest coupling with the Higgs boson

Can help answer many questions

- Higgs boson mass?
- More than three fermion generations?
- Charged Higgs bosons?
- New massive particles?
- Do all quarks have the expected couplings?
- Unknown unknowns??



Simply put: top quark sector is one of the best places to look for new physics

Tevatron's Research Program

Competitiveness

- Single top production
- EW processes and couplings
- High XT gluons

Complementarity

- ttbar spin corelations
- ttbar FB asymmetry
- W asymmetry

....

Higgs

Hints& Excesses

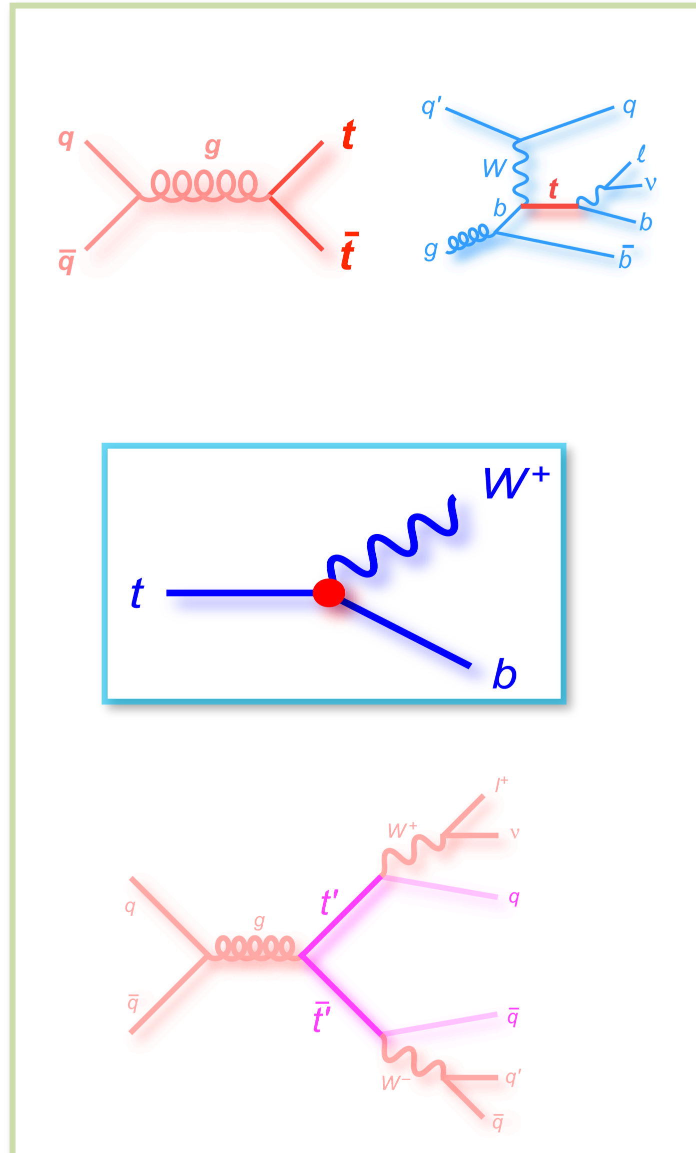
- T', Z' searches
- Ttbar FB asymmetry
- CP violation in Bs

Legacy

- Top quark mass
- Top quark properties
- W mass

Things I will Talk About Today

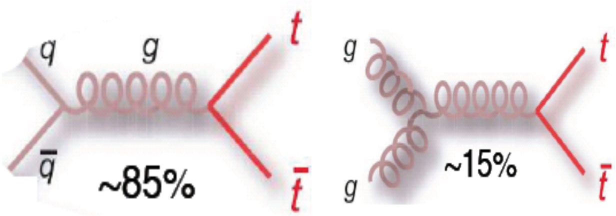
- **New physics in properties**
  - Cross section
  - Mass
  - Width
  - Spin
  - Forward backward assymtery
- **New physics in couplings**
  - Wtb couplings
  - W helicity
- **New Physics in the form of new particles**
  - ttbar resonances
  - 4^{th} generation? (looking for t')
  - Color flow



Top Quark Production at Tevatron

Top quark pair production

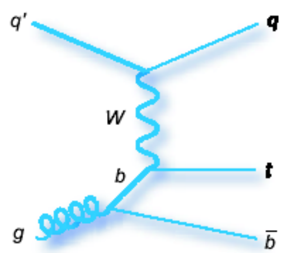
σ_{tt} ~7.5 pb



Single Top quark production

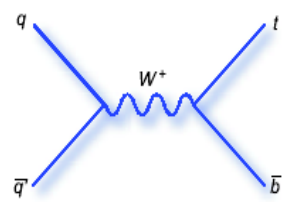
***t*-channel**

σ ~2 pb

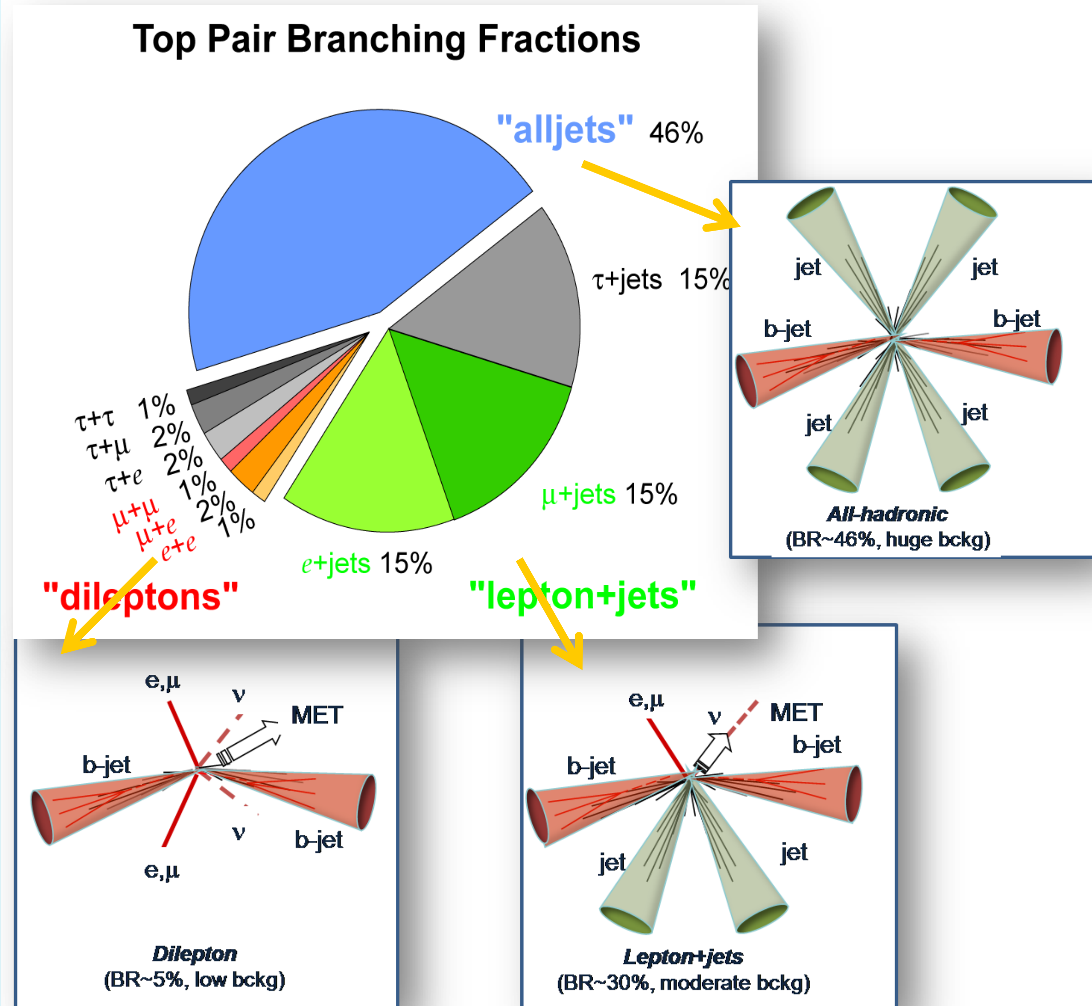


***s*-channel**

σ ~1 pb

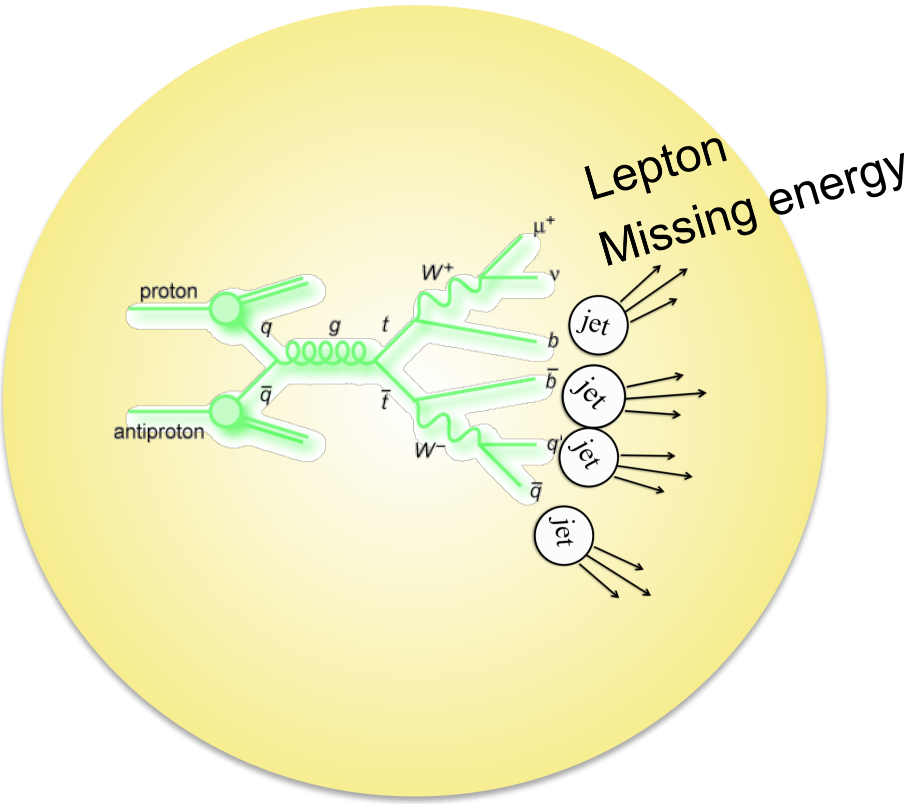


Within Standard Model t→Wb ~ 100%

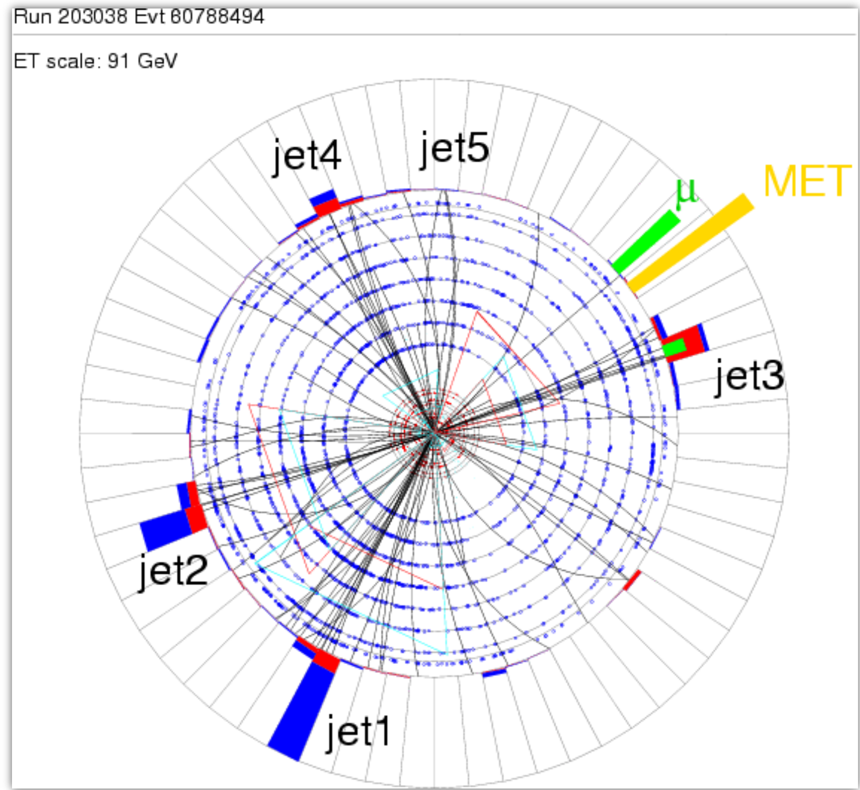


What our "Eyes" See

Theory world



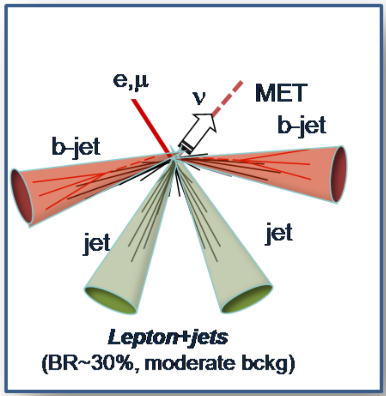
Dectector world

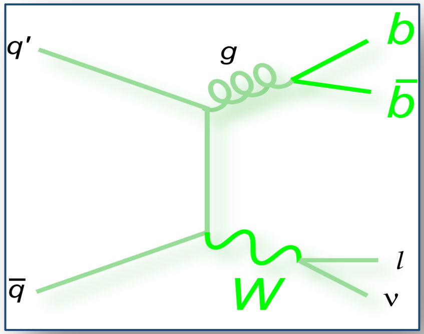


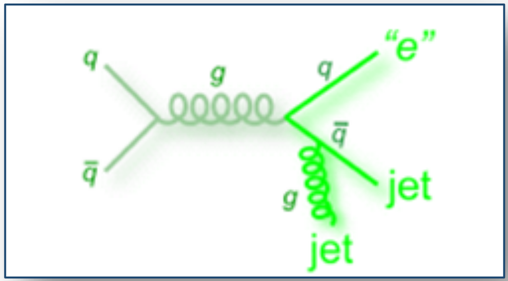
Background

- Dominant Backgrounds
  - Dominant backgrounds arise from W+jets and multijet production (ℓ+jets channel) and Z+jets WW+jets (dilepton channel)
  - When searching for new physics in top sector, SM top quark production itself becomes the dominant background

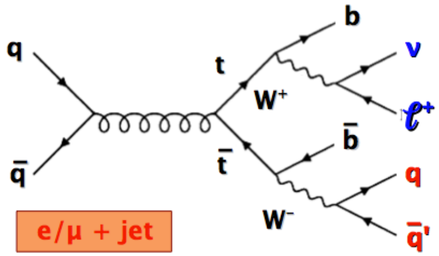
- Signal and Background Modeling
  - The SM top pair samples are generated with ALPGEN for the matrix elements and parton showers followed by PYTHIA for the hadronization
  - Single top quarks production is modeled using SINGLETOP based on COMPHEP
  - Other backgrounds are also modeled using ALPGEN or PYTHIA except multijet background which is determined from data



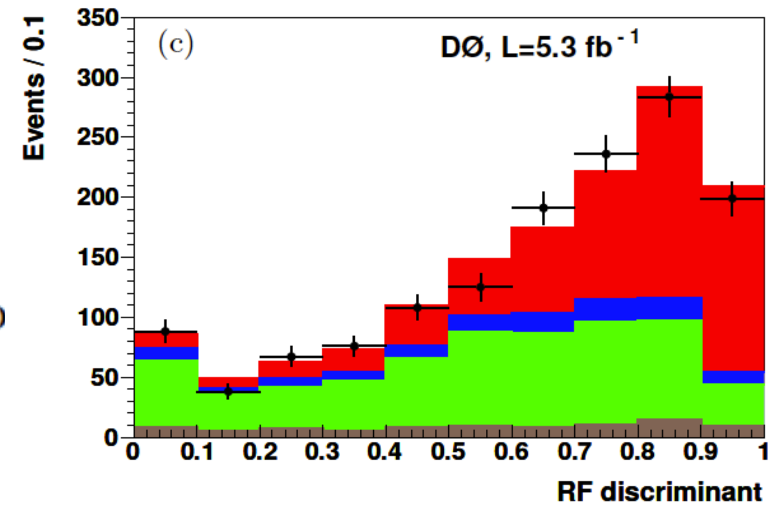




Top Pair Cross Section



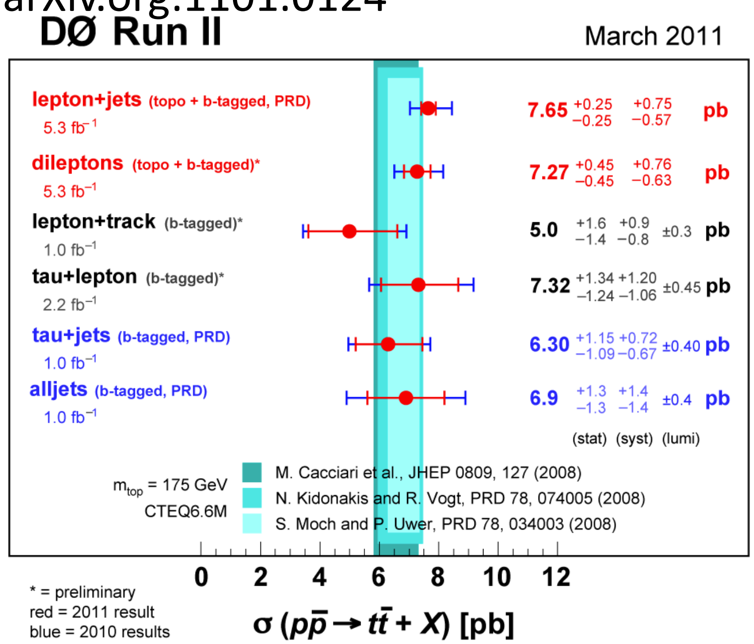
$$\sigma_{t\bar{t}} = \frac{N_{data} - N_{bck}}{\varepsilon . L . A}$$

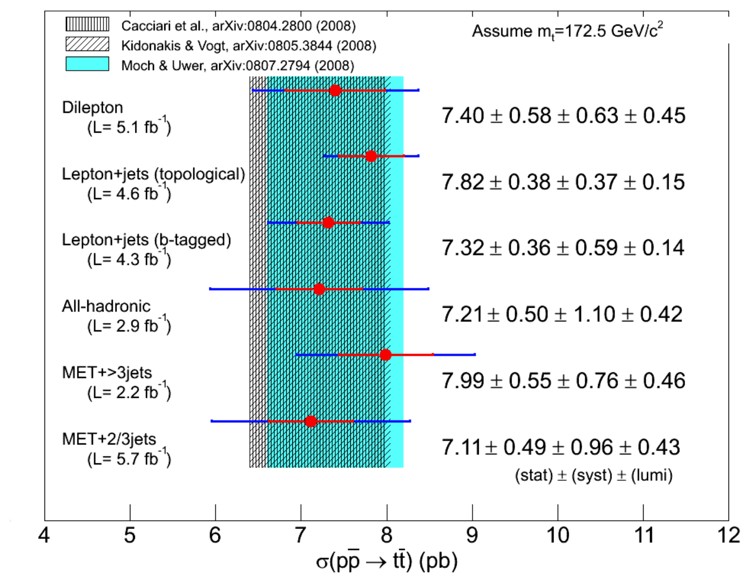


$$\sigma_{t\bar{t}} = 7.78^{+0.77}_{-0.64} (\mathrm{stat + syst + lumi})\ \mathrm{p}$$

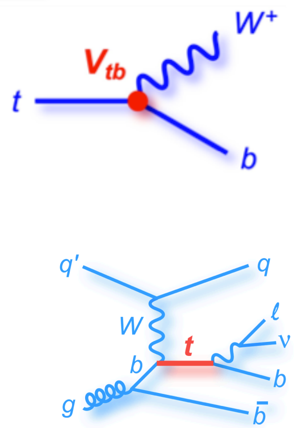
With 5.3 fb-1, for a mass of 172.5 GeV

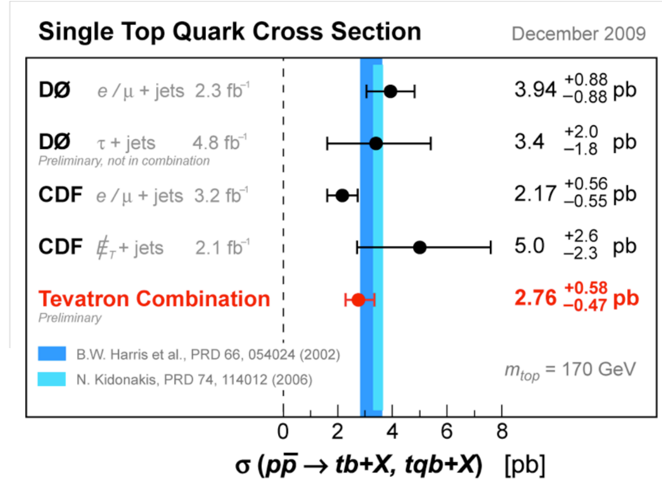
arXiv.org:1101.0124

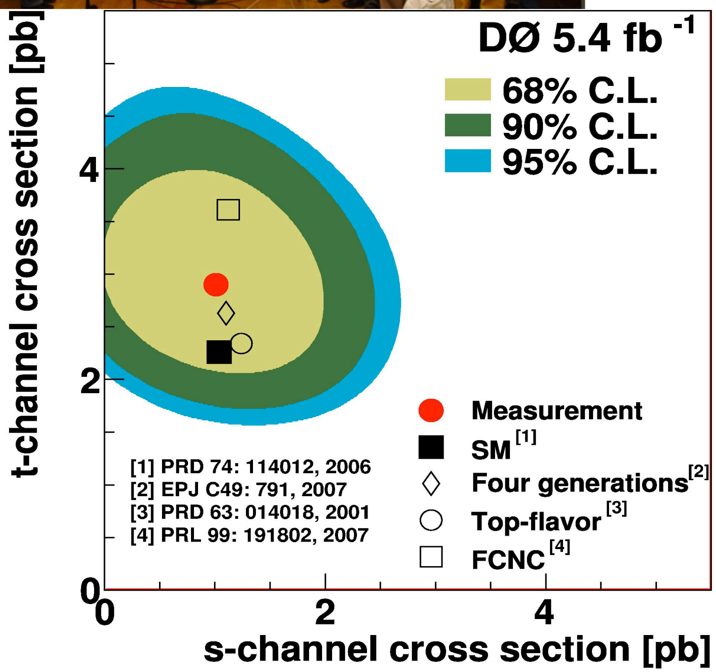




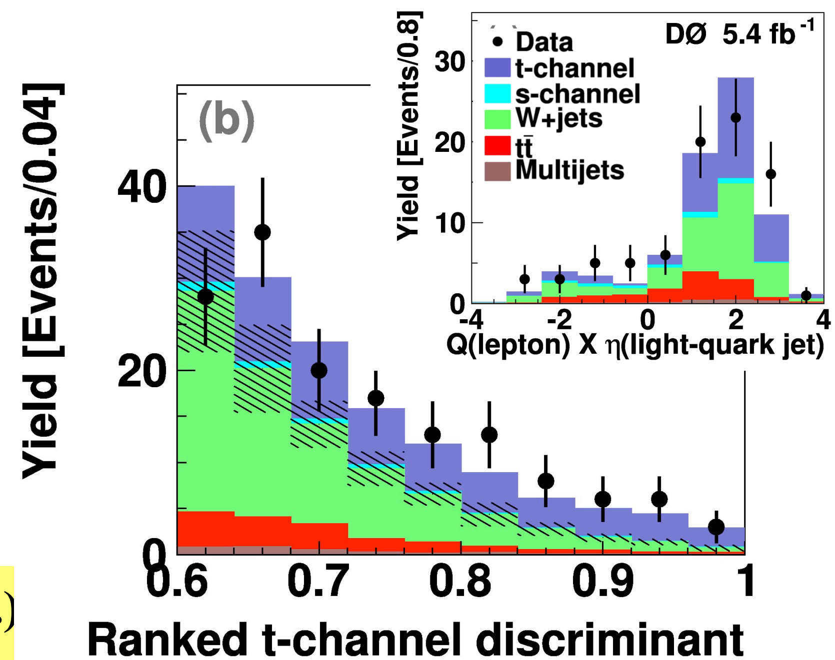
Single Top Cross section





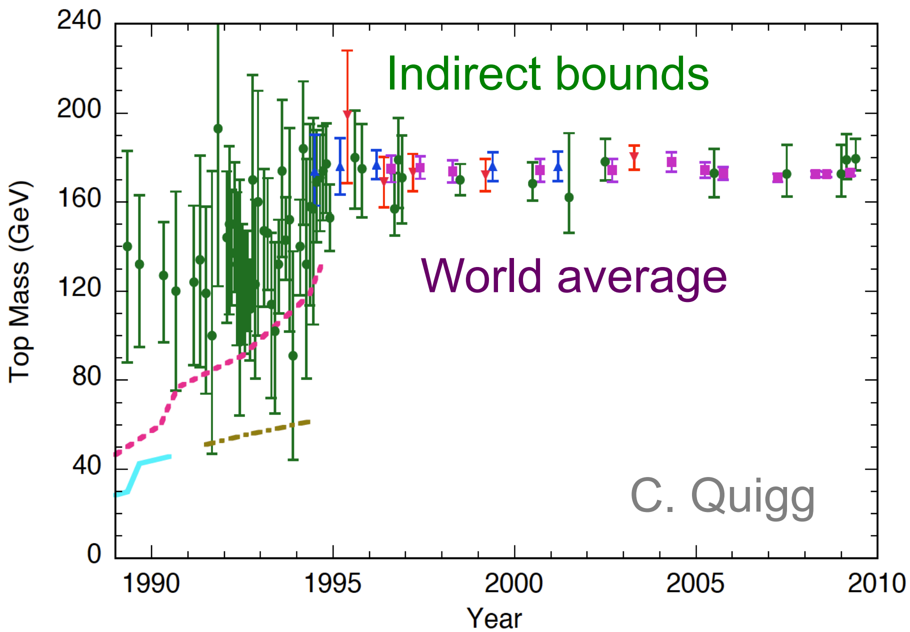


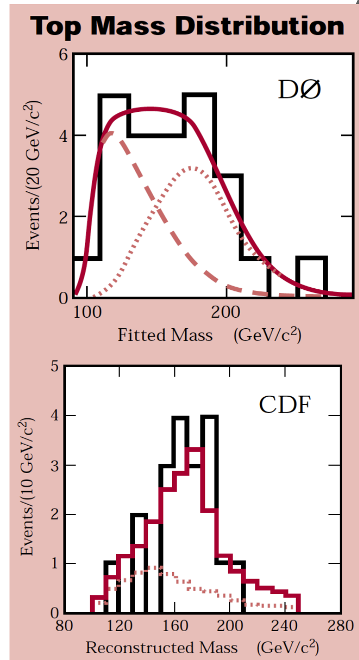
σ_{tqb} = 2.90 ± 0.59 pb (5.5 std. dev.)

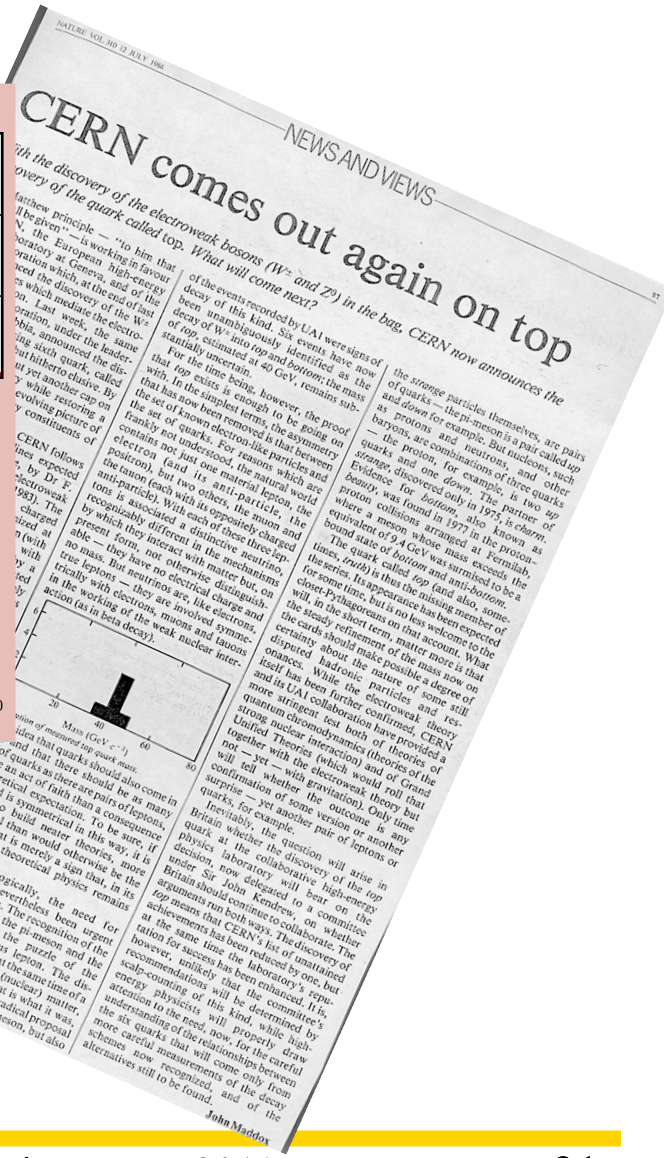


Top Quark Mass

…indeed a very long tale







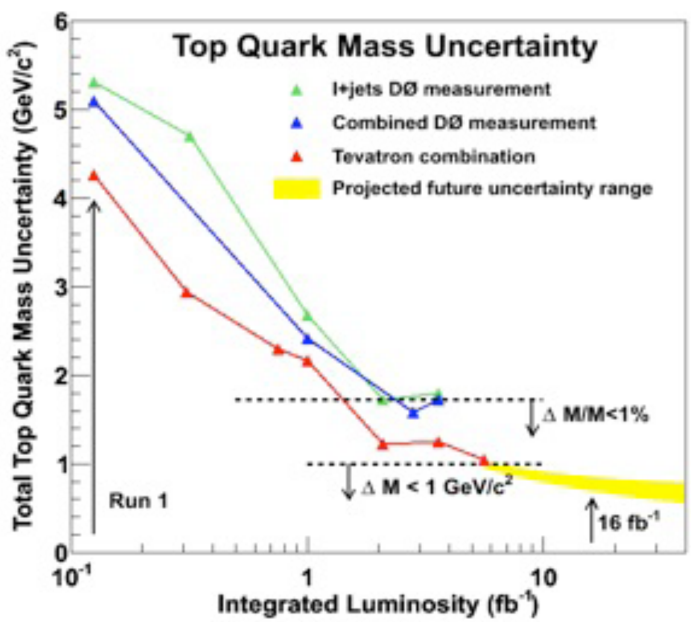
Top Quark Mass

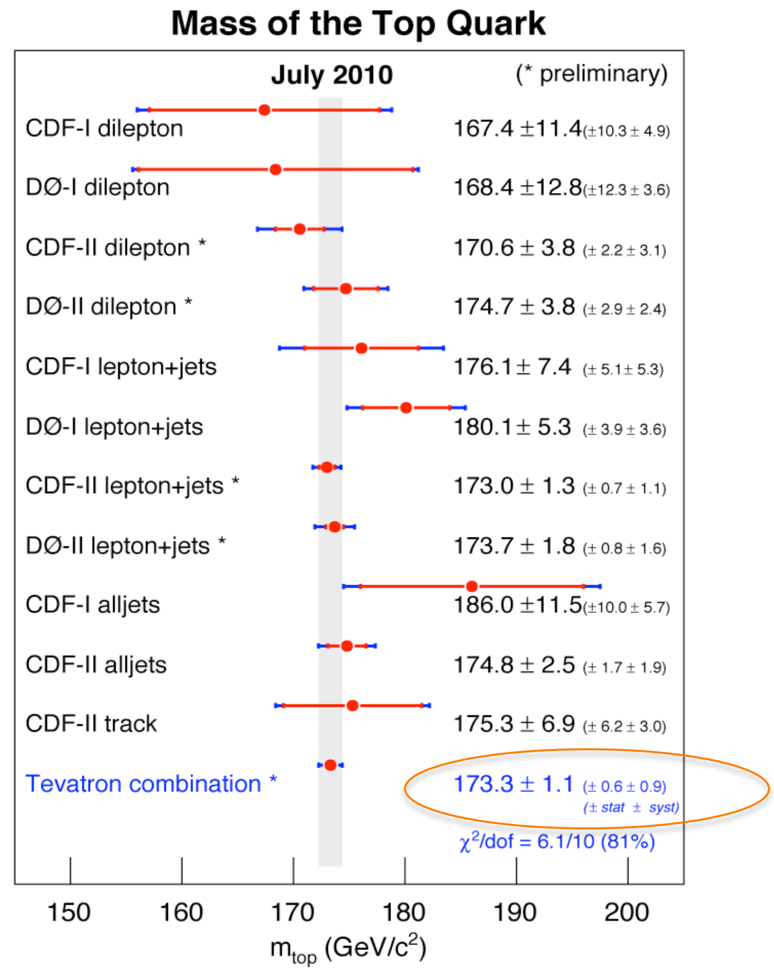
- Top quark mass is measured directly
  - in different channels

    Dilepton, lepton+jets, all jets channels

  - using a variety of techniques by both CDF and DØ

- Both experiments are in agreement





Measured top mass = 173.3±1.1 GeV

We have long exceeded the Tevatron goal of δM=2 GeV

Top Quark Mass

$$\mathcal{L} = \ldots - \bar{\psi} M \psi \left(1 + \frac{H}{v}\right) \ldots$$

m_{top}

- **LO QCD: free parameter**
- **NLO QCD: dependent on the renormalisation scale M**

"Bare" parameters of QCD:

$g_s, m_u, m_d, m_s, m_c, m_b, m_t$

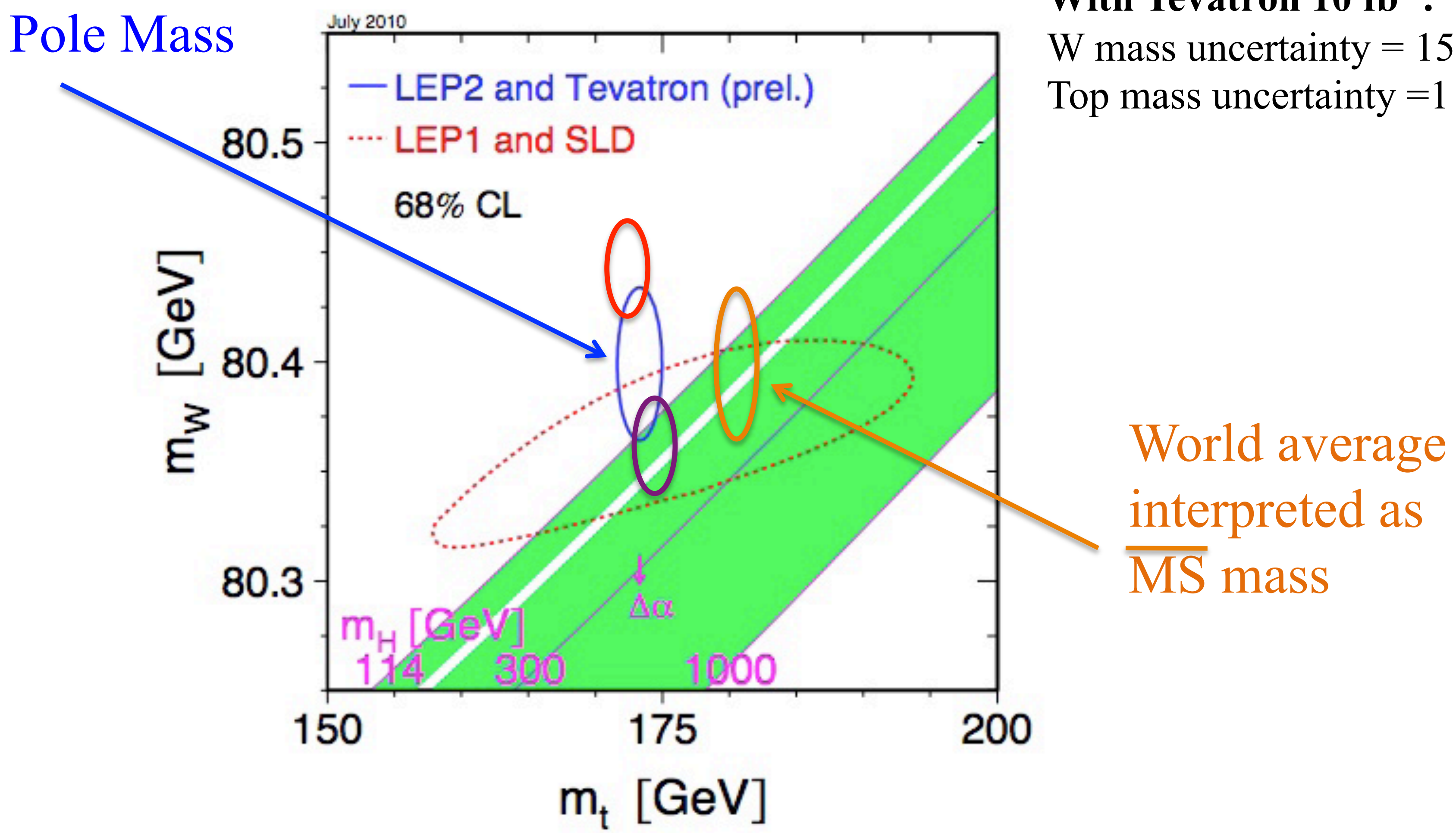
Renormalised parameters of QCD:

$g_s(M), m_u(M), m_d(M), m_s(M), m_c(M), m_b(M), m_t(M)$

<u>the concept of quark mass is convention-dependent!</u>

There are theoretical arguments that our measured mass from MC is closer to the pole mass within 1GeV. But how close?

SM Self Consistency



With Tevatron 10 fb^{-1}:

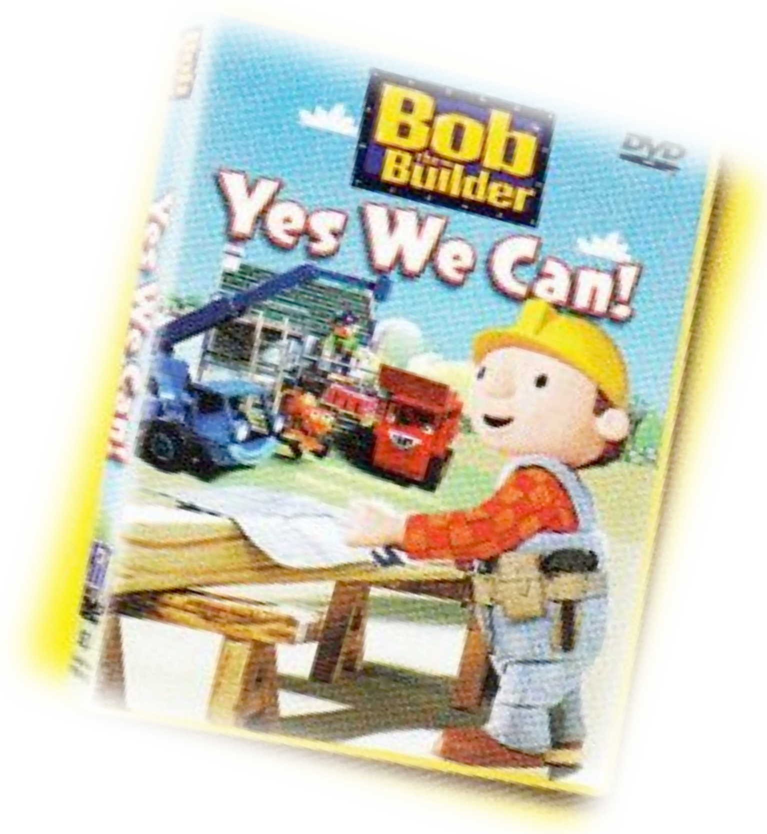
W mass uncertainty = 15 MeV

Top mass uncertainty =1 GeV

The top mass depends on M_H through loop diagrams ($M_t \sim \log M_H$).

Can we do Anything about it?

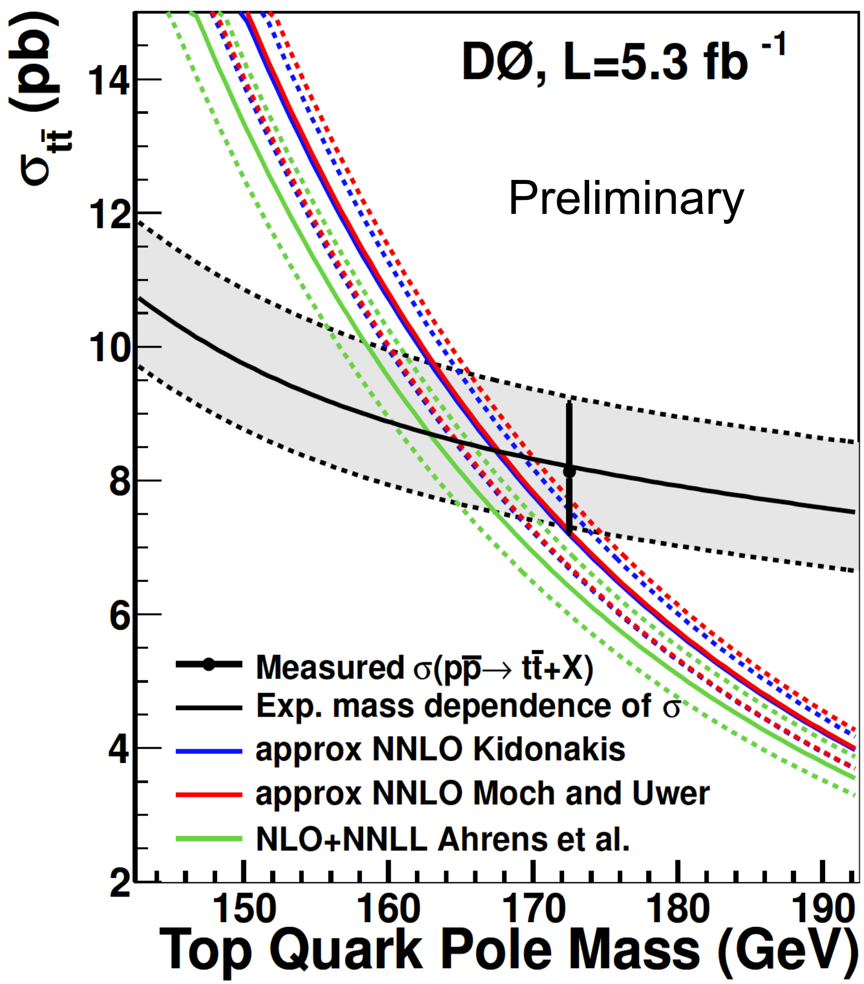
Yes we can!

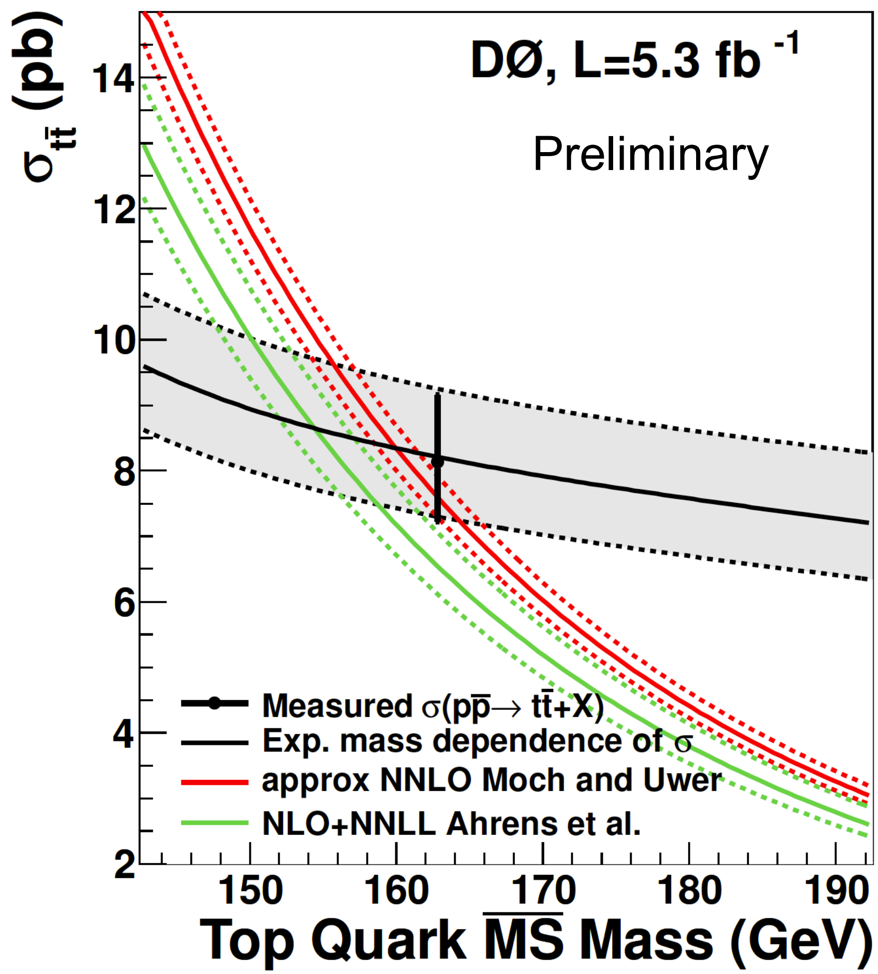


No! it's not Obama….

Top Quark Mass from Cross Section

Compare the experimental value for cross-section as function of top mass with theoretical calculations in pole and MS-bar schemes





Top Quark Mass from Cross Section

- We extract the most probable top quark mass values in pole and MS-bar schemes and corresponding 68% CL bands

Theoretical Calculation	Measured Mass	
	Pole mass	MS-bar mass
NLO+NNLL	163.0+5.4 -4.9	154.4+5.2-4.5
Approx. NNLO	167.5+5.4-4.9	159.9+5.1-4.4

NNLO approx Moch and Uwer
NLO+NNLL Ahrens et al.

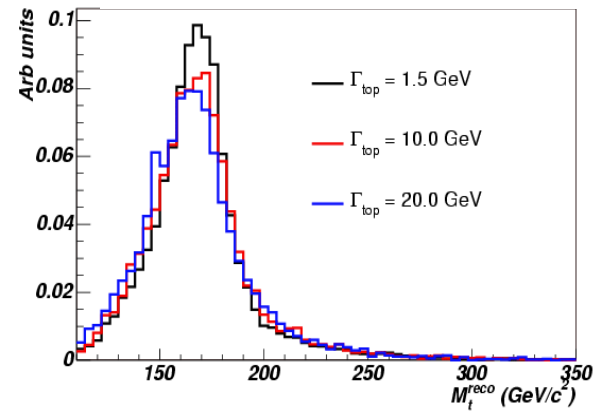
Directly measured top quark mass = 173.3±1.1 GeV

- For the first time the top quark MS-bar mass is extracted taking the mass dependence of the measured top-antitop cross section correctly into account

Top Quark Width

SM predicts ~1.5 GeV (Mt = 175 GeV)

Lepton+Jets with 4.3fb^{-1}



CDF Template based top width measurement

- Upper limit placed on top width

$$0.4\ \text{GeV} < \Gamma_{top} < 4.4\ \text{GeV @ 68\% CL}$$
$$\Gamma_{top} < 7.5\ \text{GeV @ 95\% CL}$$

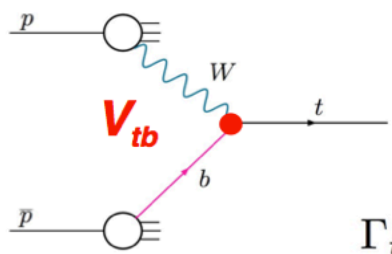
- **Use t-channel single top quark production and top decay branching ratio measurements**

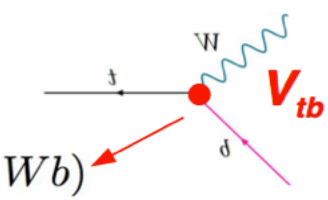
t-channel cross section:

σ(t-channel) = 2.14 ± 0.18 pb
NLO, m_t = 170 GeV

partial decay width:

Γ(t→Wb) = 1.26 GeV
NLO, m_t = 170 GeV





$$\sigma(t\text{-channel})\,\mathcal{B}(t\to Wb) = 3.14^{+0.94}_{-0.80}\ \text{pb}$$

$$\Gamma_t = \frac{\Gamma(t\to Wb)}{\mathcal{B}(t\to Wb)}$$

tt̄ production

$$\mathcal{B}(t\to Wb) = 0.962^{+0.068}_{-0.066}(\text{stat})\ ^{+0.064}_{-0.052}(\text{syst})$$

assume that coupling in top production and decay is the same

$$\Gamma(t\to Wb) = \sigma(t\text{-channel})\,\frac{\Gamma(t\to Wb)_{SM}}{\sigma(t\text{-channel})_{SM}}$$

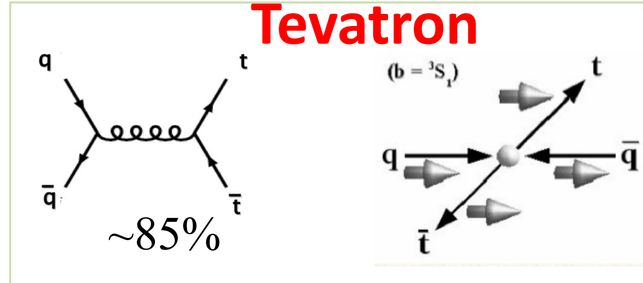
$$\Gamma_t = 1.99^{+0.69}_{-0.55}\ \text{GeV}$$

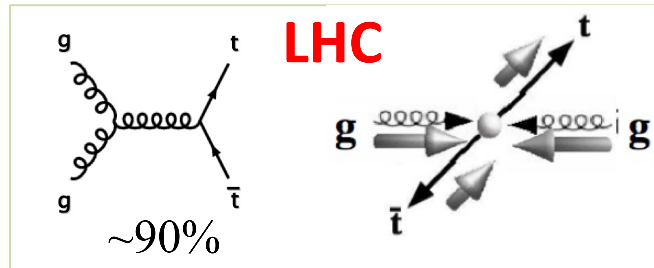
$$\tau_t = (3.2^{+1.3}_{-0.9})\times 10^{-25}\ \text{s}$$

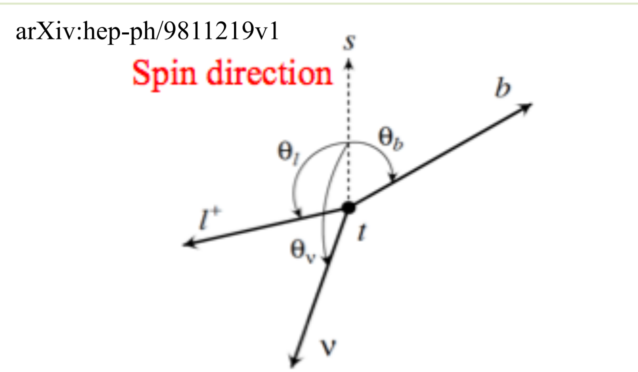
⇒ most precise determination

Spin Correlation in ttbar Events

- In top pair production at hadron colliders, their spins are expected to be correlated
- Observation of spin correlation will place upper limit on top quark life time
- Scenarios beyond the standard model predict changes in production and decay dynamics to change effect of spin correlation
- Complementary to LHC







Decay product	Correl Coeff.
b	-0.40
ν_ℓ, u, or c	-0.33
$\bar{\ell}$, $\bar{d}$, or $\bar{s}$	1.00

- Maximum correlation for charged lepton or down type quark
  - Use dilepton decay channel
- Choosing the beam momentum vector as the quantization axis

The NLO QCD prediction

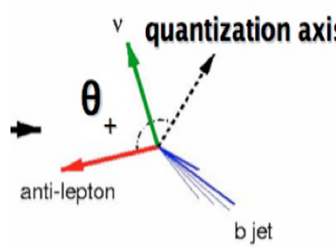
C = 0.777+0.027-0.042

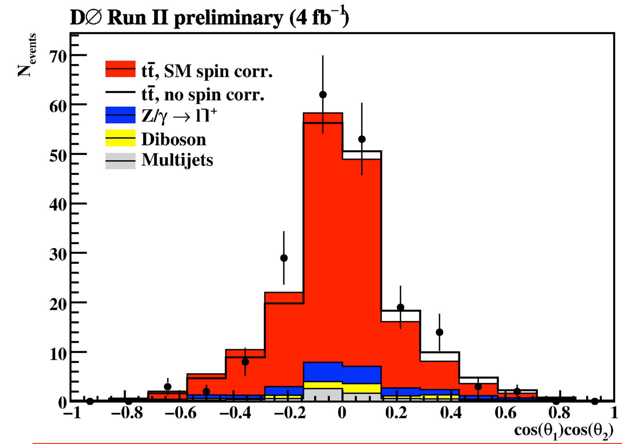
Measuring Spin Correlations

- **Using templates**

C

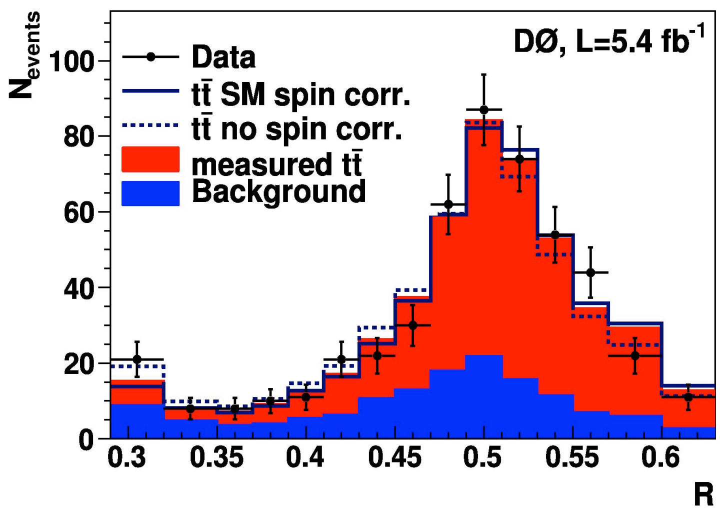
$$K = \frac{N(\uparrow\uparrow)+N(\downarrow\downarrow)-N(\uparrow\downarrow)-N(\downarrow\uparrow)}{N(\uparrow\uparrow)+N(\downarrow\downarrow)+N(\uparrow\downarrow)+N(\downarrow\uparrow)}$$





$$C = 0.10^{+0.45}_{-0.45}\,(\mathrm{stat+syst})$$

- **Using matrix element spin of the top**



$$R = \frac{P_{\mathrm{sgn}}(H=c)}{P_{\mathrm{sgn}}(H=u)+P_{\mathrm{sgn}}(H=c)}$$

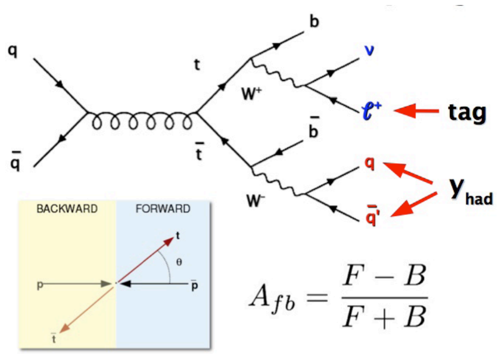
Exclude the hypothesis that the spins of the t¯t are uncorrelated at the 97.7% C.L.

A_{fb} in Top Quark Events

- SM predicts no asymmetry in LO in QCD – NLO prediction is 2±1%

$$A_{fb} = \frac{N(\Delta y>0)-N(\Delta y<0)}{N(\Delta y>0)+N(\Delta y<0)}$$

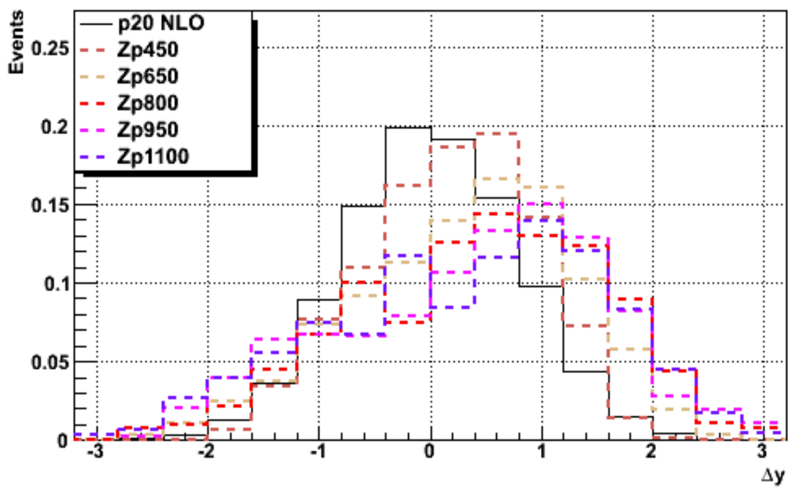
- Large measured asymmetry would indicate new physics

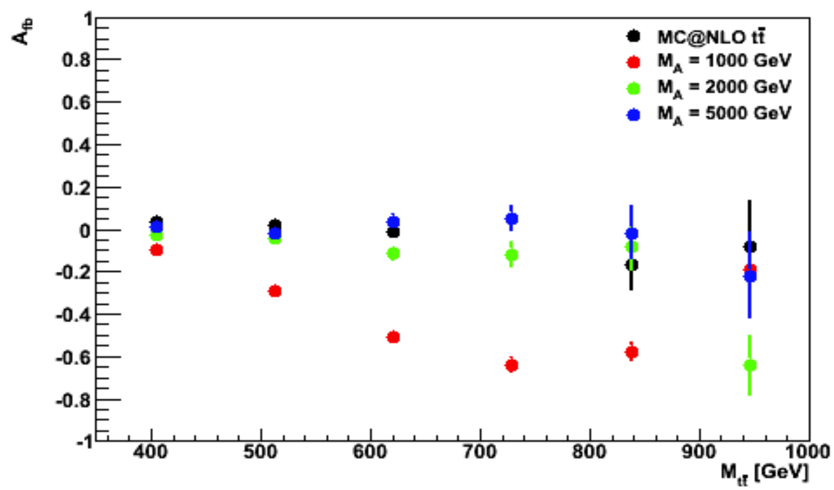


$$A_{fb} = \frac{F-B}{F+B}$$

The asymmetry gives us a window into many types of potential new physics: $Z' \to t\bar{t}$, Axigluons and extra dimensions.

For Axigluons, can potentially get a limit of 2 TeV or more.

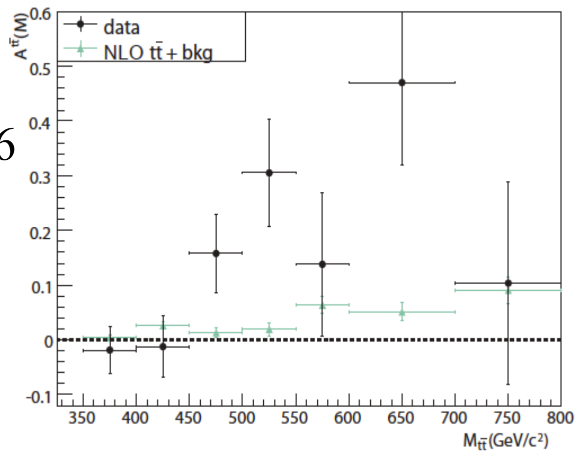


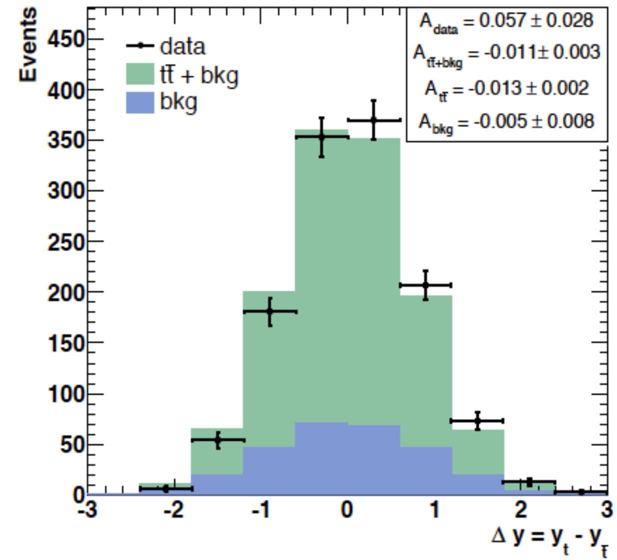


The Tevatron A_{fb} measurements are complimentary to the LHC

A_{fb} in Top Quark Events

arXiv:1101.0034v1 [hep-ex]





MCFM predictions of 0.039 ±0.006

$$A^{t\bar{t}}(|\Delta y| < 1.0) = 0.026 \pm 0.118$$
$$A^{t\bar{t}}(|\Delta y| \geq 1.0) = 0.611 \pm 0.256$$

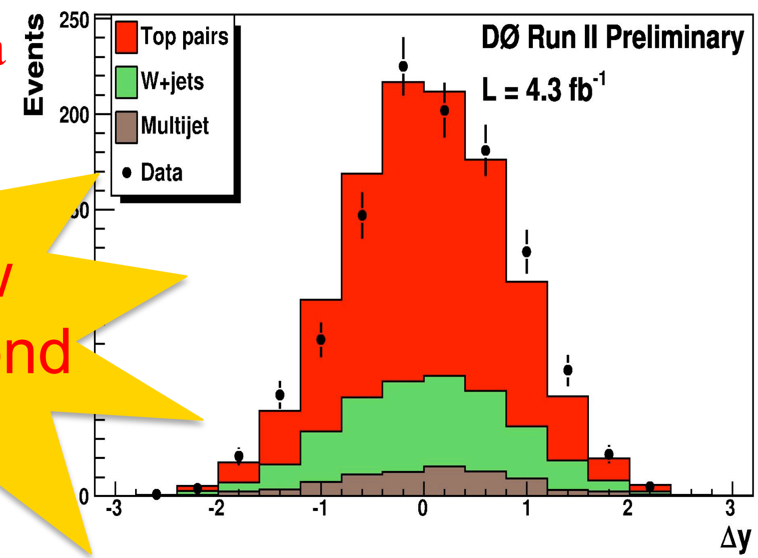
$$A^{t\bar{t}}(M_{t\bar{t}} < 450\ \mathrm{GeV}/c^2) = -0.116 \pm 0.153$$
$$A^{t\bar{t}}(M_{t\bar{t}} \geq 450\ \mathrm{GeV}/c^2) = 0.475 \pm 0.114$$

current preliminary result:

Afb = 8±4(stat) ±1(syst))% for 4.3 fb^{-1} of data

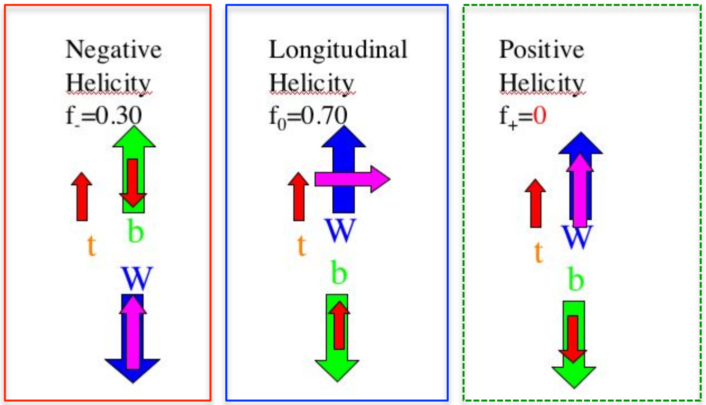
Disagreement between top pair pT for data and simulation

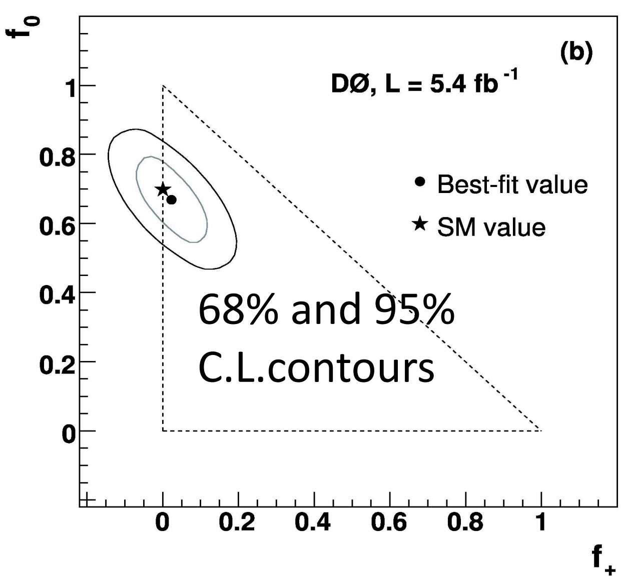
Hint of new physics beyond SM?

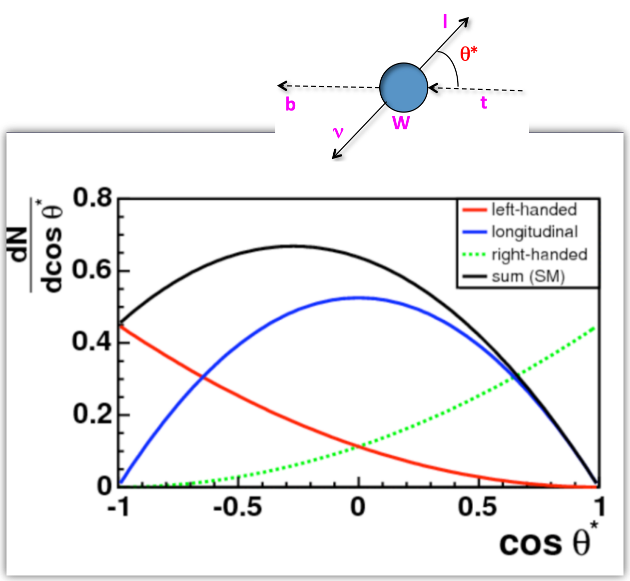


W Boson Helicity

- Model-independent measurement of the W boson helicity from t→Wb decays in top pair productio
- In the SM, the top quark decays via the V −A charged-current interaction, almost always to a W boson and a b quark







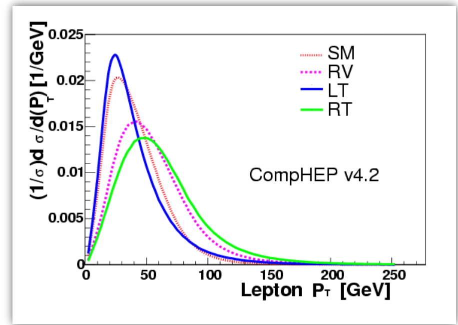
$$f_0 = 0.490 \pm 0.106\,(\text{stat.}) \pm 0.085\,(\text{syst.})$$
$$f_+ = 0.110 \pm 0.059\,(\text{stat.}) \pm 0.052\,(\text{syst.})$$

W Helicity and Anomalous Couplings

- General Analysis of Single Top Production and W Helicity in Top Decay
  Ren, Larios, and C. P. Yuan (PLB 631, 126 (2005))

$$L_{tWb} = \frac{g}{\sqrt{2}} W_\mu^- \bar{b}\gamma^\mu \left(f_1^L P_L + f_1^R P_R\right) t - \frac{g}{\sqrt{2}M_W} \partial_\nu W_\mu^- \bar{b}\sigma^{\mu\nu}\left(f_2^L P_L + f_2^R P_R\right) t + h.c.$$

where, in the SM $f_1^L \approx 1,\ f_2^L = f_1^R = f_2^R = 0$

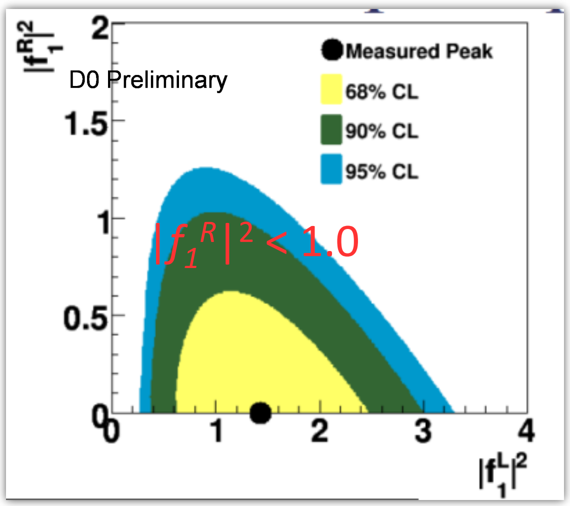


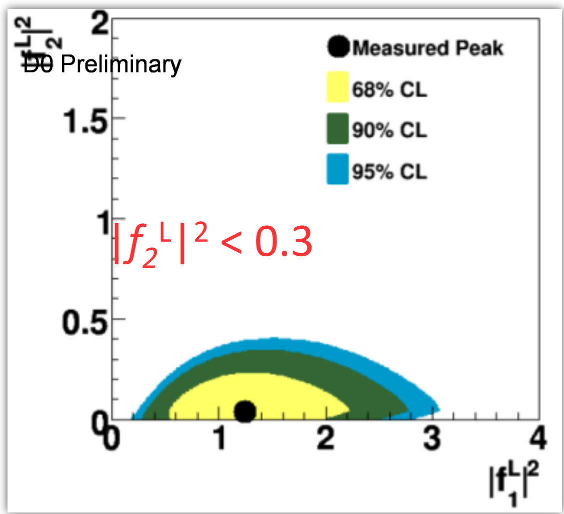
- Combine W helicity measurement in top pair decays
  (PRL 100 , 062004 (2008))

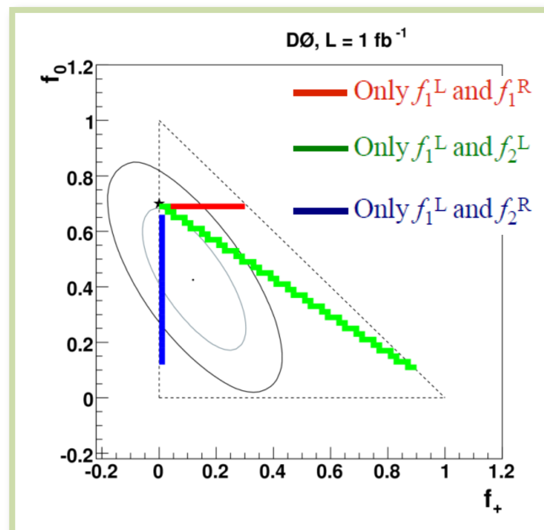
  with

- Anomalous couplings measurement in single top
  (PRL 101, 221801 (2008))

$$f_{0,\mathrm{meas}} - f_0\left(f_1^L, f_2^L, f_1^R, f_2^R\right)$$
$$f_{+,\mathrm{meas}} - f_+\left(f_1^L, f_2^L, f_1^R, f_2^R\right)$$
$$\Delta\sigma_{\mathrm{s,\,meas}} - \Delta\sigma_s\left(f_1^L, f_2^L, f_1^R, f_2^R\right)$$
$$\Delta\sigma_{\mathrm{t,\,meas}} - \Delta\sigma_t\left(f_1^L, f_2^L, f_1^R, f_2^R\right)$$



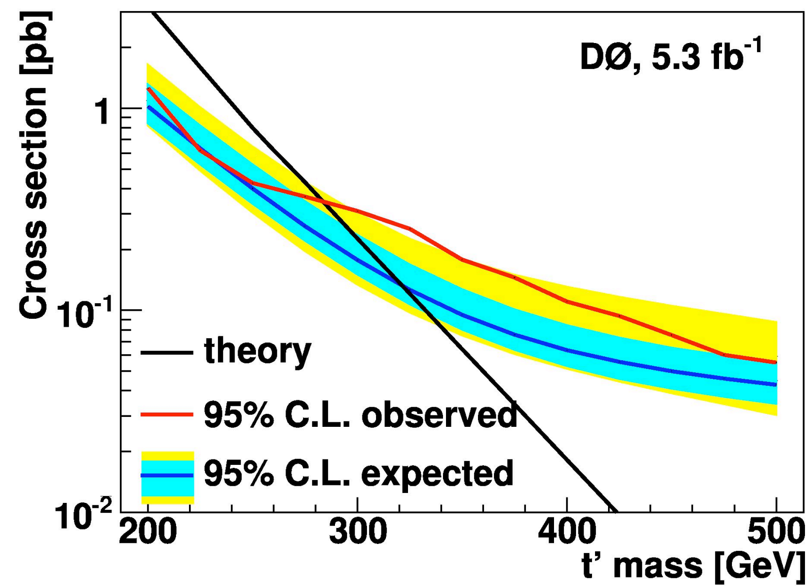


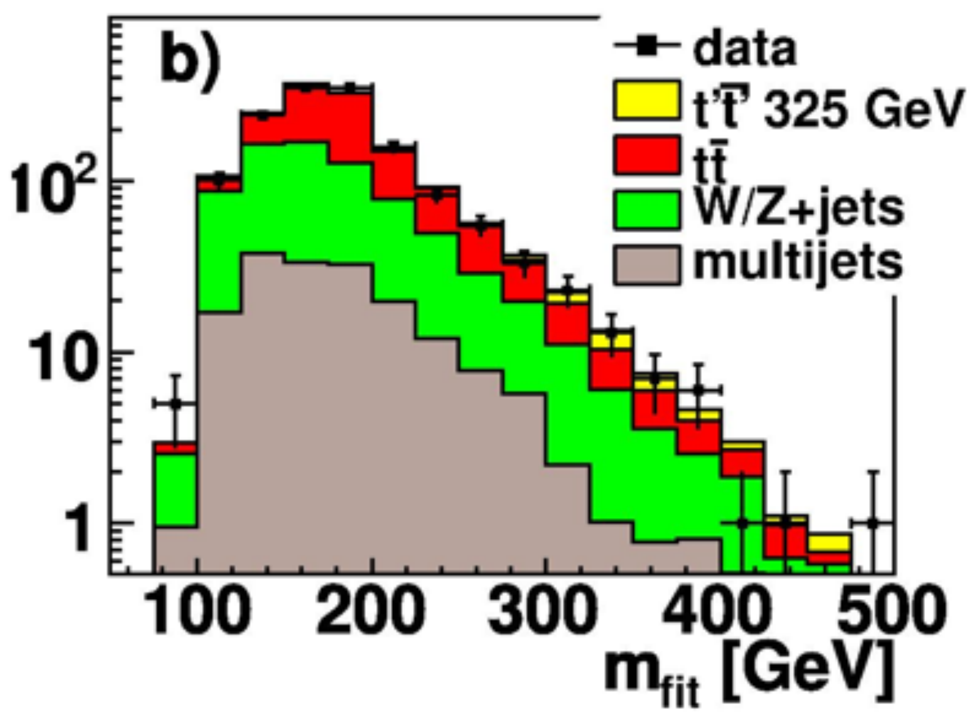


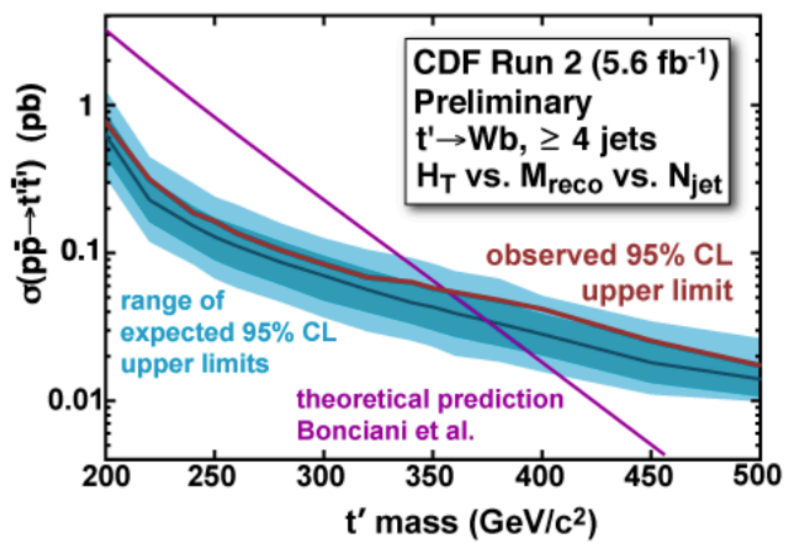
Search for 4^{th} Generation Heavy Quark

Search for fourth generation quark, t'

- More massive than top quark
- assume $m_{t'} - m_{b'} < m_W$ and B(t'→Wb) = 100%
- @10TeV 200/pb muon+jets only CMS can exclude $M_{t'}$<400 GeV

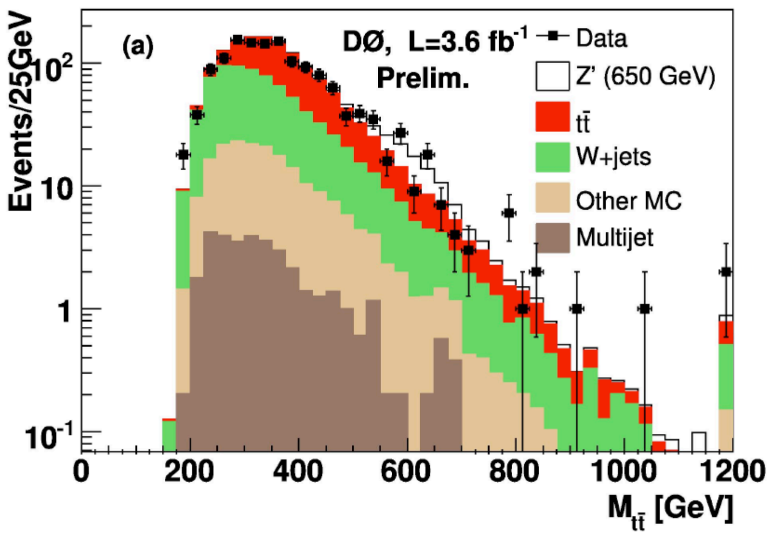


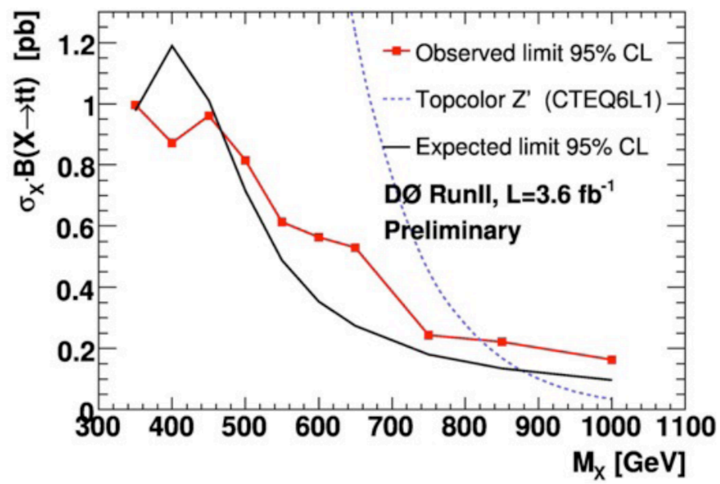




Search for Heavy Resonanaces

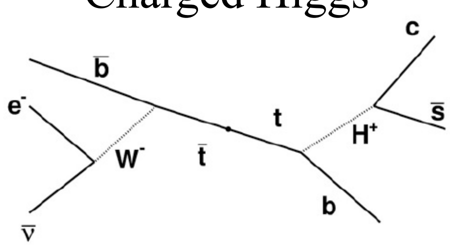
- Top-antitop resonance
  - Search for excess in ttbar invariant mass distributions from Z' boson
  - Analysis just started but since basic selection and systematics samples can be reused from t' analysis we should have a publication soon



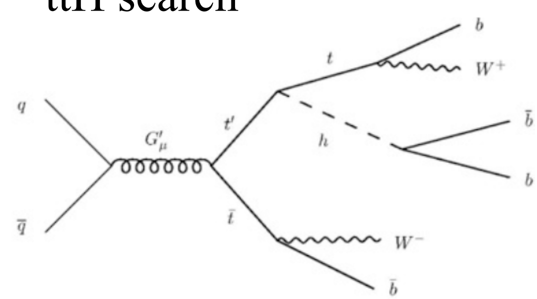


- Possible future searches with ttbar signatures

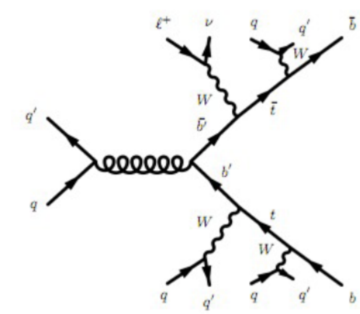
Charged Higgs



ttH search



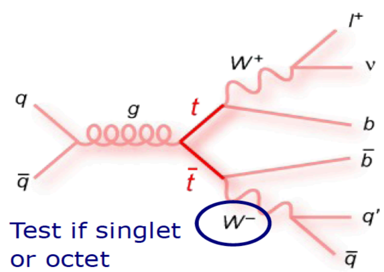
b' search

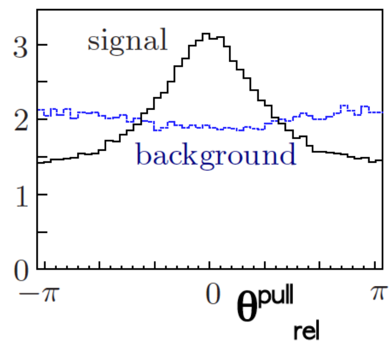


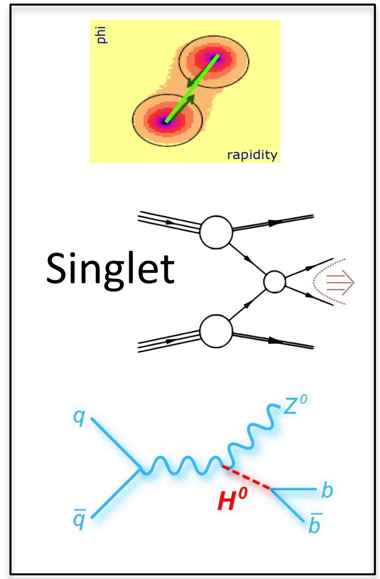
Color Flow

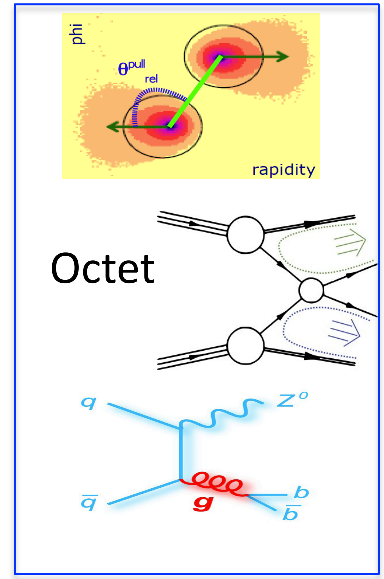
- Jet shape influenced by color flow
- Shape influenced by direction of color flow!
  - Distinguish processes with same final state

Gallicchio,Schwartz, PRL 105, 02200(2010)





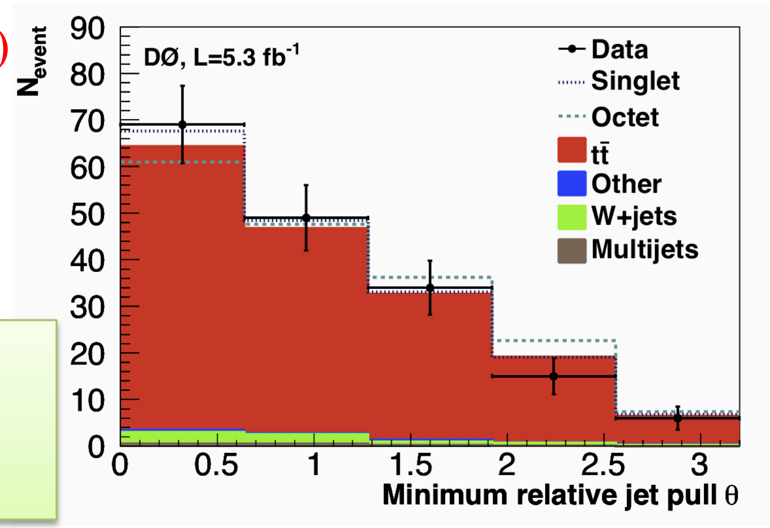




Fraction of singlet=0.56±0.38(stat+syst)±0.19(MC stat)

Expected: Exclude octet "W" @ 99%C.L.

Expect $f_{Singlet}$=1 in SM



First study of color flow in tt events
First extraction of $f_{Singlet}$
(using only color flow information)

Summary – A tribute to Tevatron

- The Tevatron has taken us far in understanding the SM
- The degree of sophistication of object algorithms, analysis techniques and tools developed at the Tevatron will used by next generations. These advances will of course migrate to the LHC experiments.
- The legacy of the Tevatron will be in its discovery and elucidation of the top quark, W & Z physics and perturbative QCD. It still has a critical role to play in the Higgs story.

Tevatron could exclude or discover Higgs in the entire mass range favored by the electroweak fits

Tevatron has already shown how "almost impossible" can be made possible!

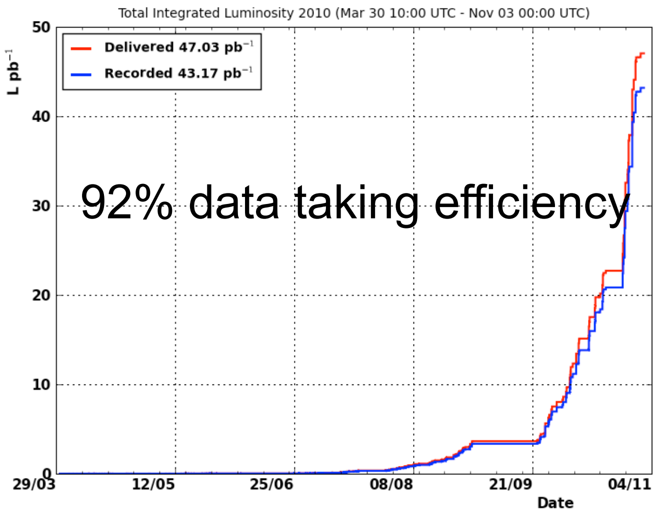
- May be some hint of new physics?(only part of data delivered has been analysed yet)

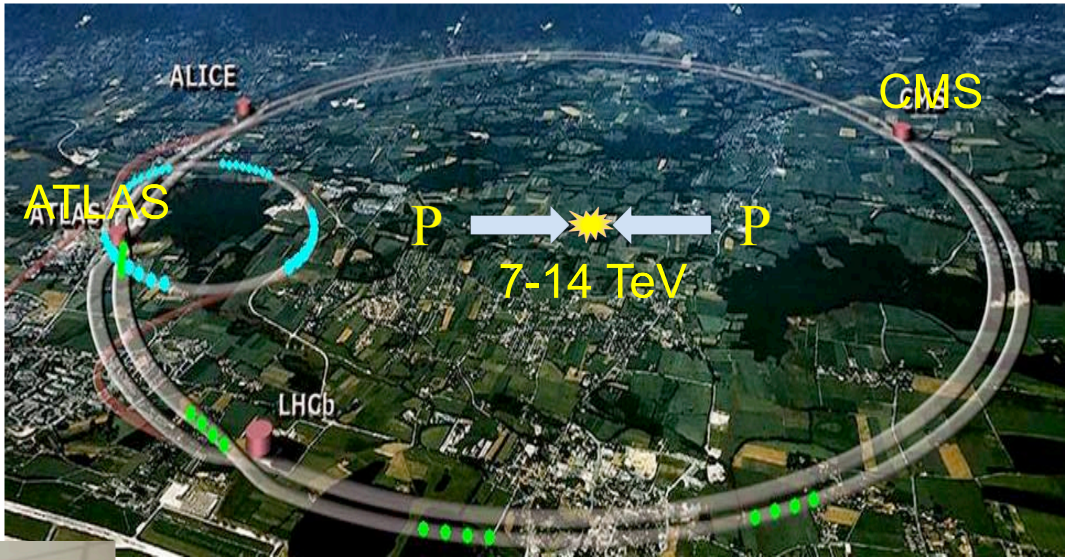
……… as far as top quark is concerned while LHC will be able to test most of the properties in detail, the legacy mass measurement and complimentary measurements at the Tevatron will still be relevant

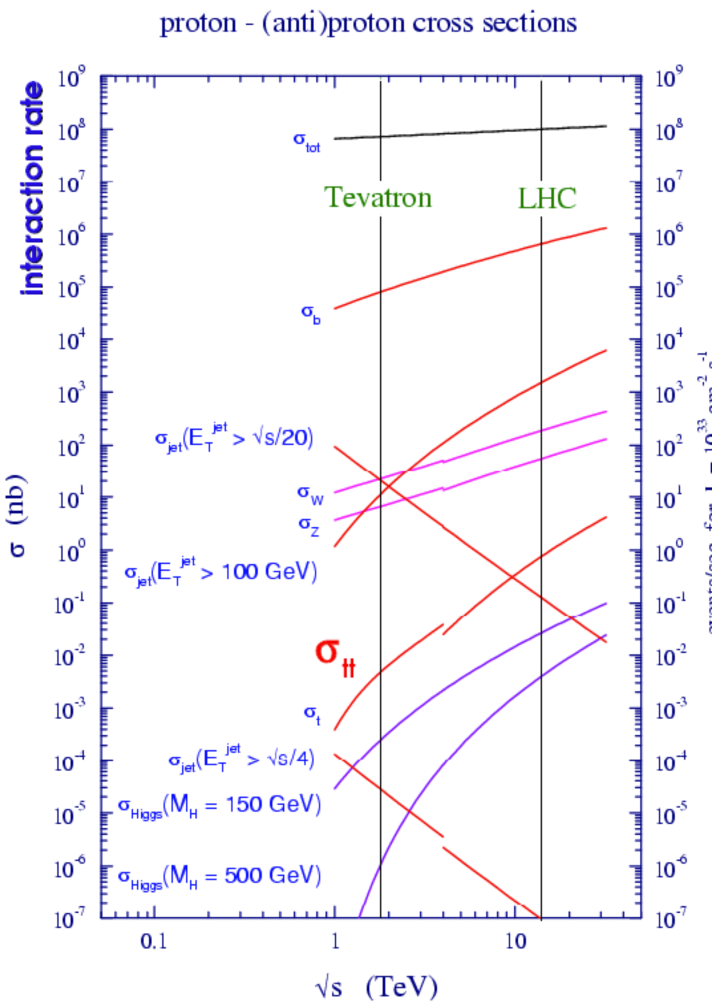
- It is a great time to be a physicist
- We had two revolutions at the turn of last century – these revolutions changed the way we look at our universe
- There are again many questions unanswered and hints will come from experiments
- With Tevatron producing exciting results, LHC finally coming online and many other experiments from under ground to outer space are giving me hope that revolution is in the air

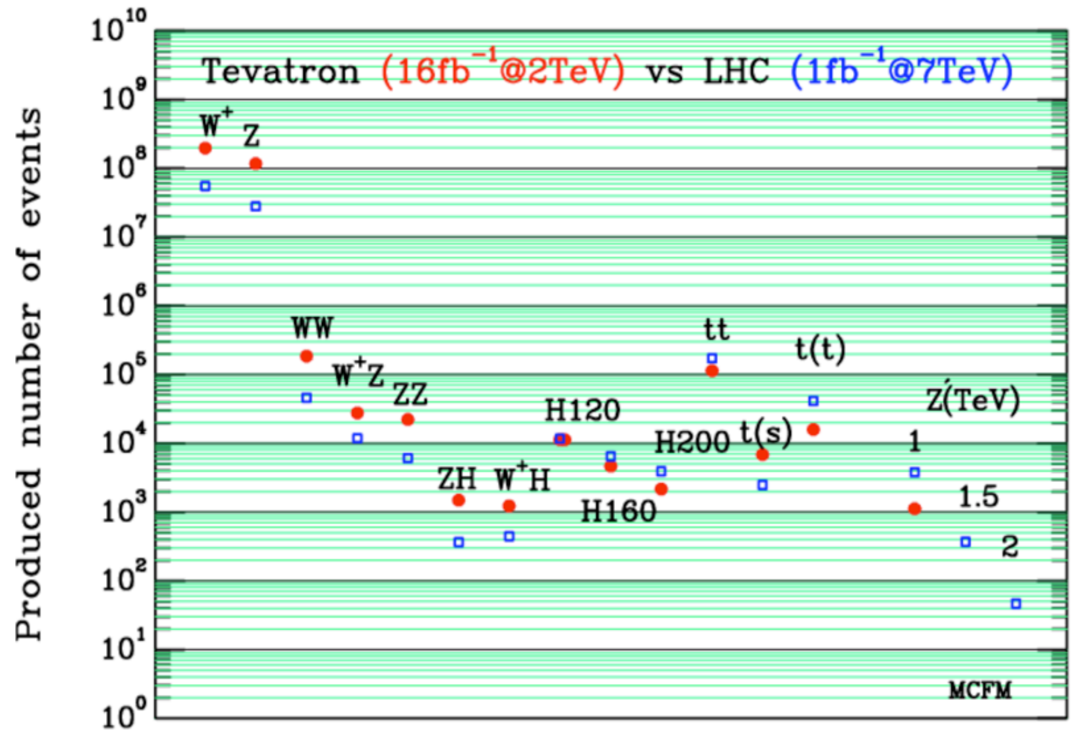
Good luck to us all!!!!

Conceived in the 1980s and approved for construction by the CERN Council in late 1994.









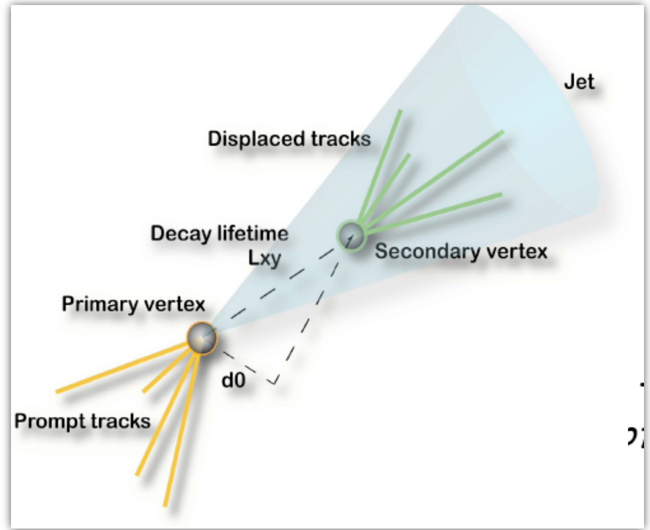
Standard model ttbar cross section at 14TeV is ~886pb

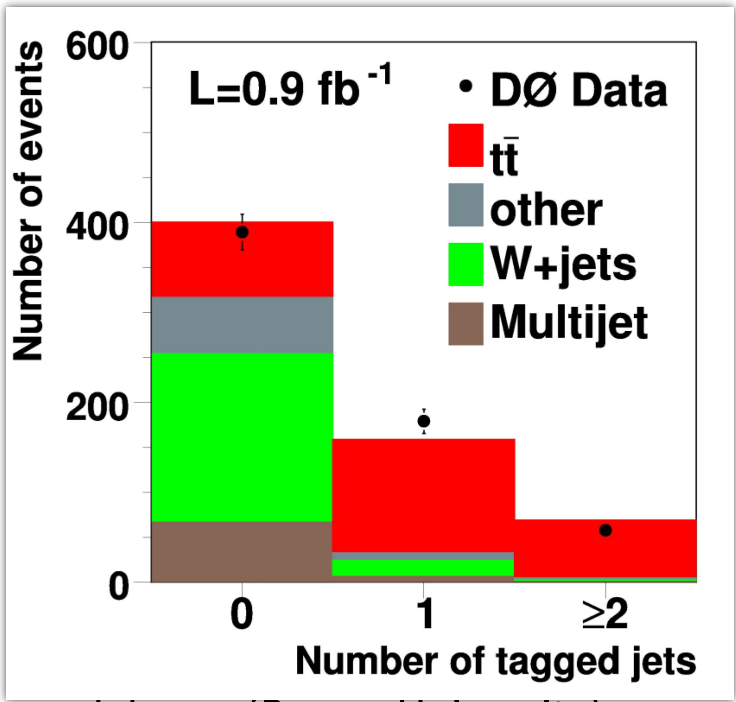
- Expected number of top pairs ~9×106 / year
- Total number of pairs seen at CDF is ~35000

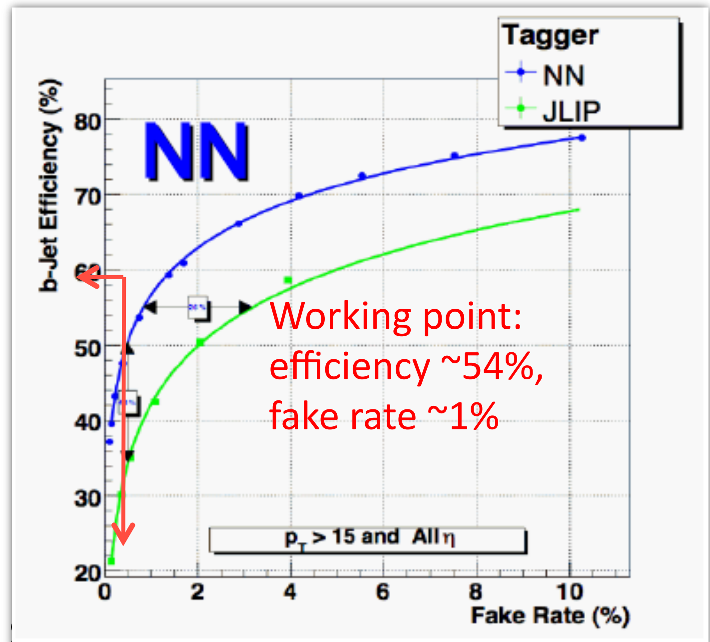
similar size of electroweak samples: top, W, Z

B Jet Identification

- *B*-hadron lifetime τ~ 1 ps
  - *B*-hadron travels L_{xy}~1 mm before decay
- Combine properties of reconstructed secondary vertices and displaced tracks in 7-variable network







Shabnam Jabeen (Brown University) HEP

$$A_C = \frac{N_t(p) - N_{\bar{t}}(p)}{N_t(p) + N_{\bar{t}}(p)}$$

Charge asymmetry: number tops and anti-tops in a given direction (proton beam)

$$A_{fb} = \frac{N_t(p) - N_t(\bar{p})}{N_t(p) + N_t(\bar{p})}$$

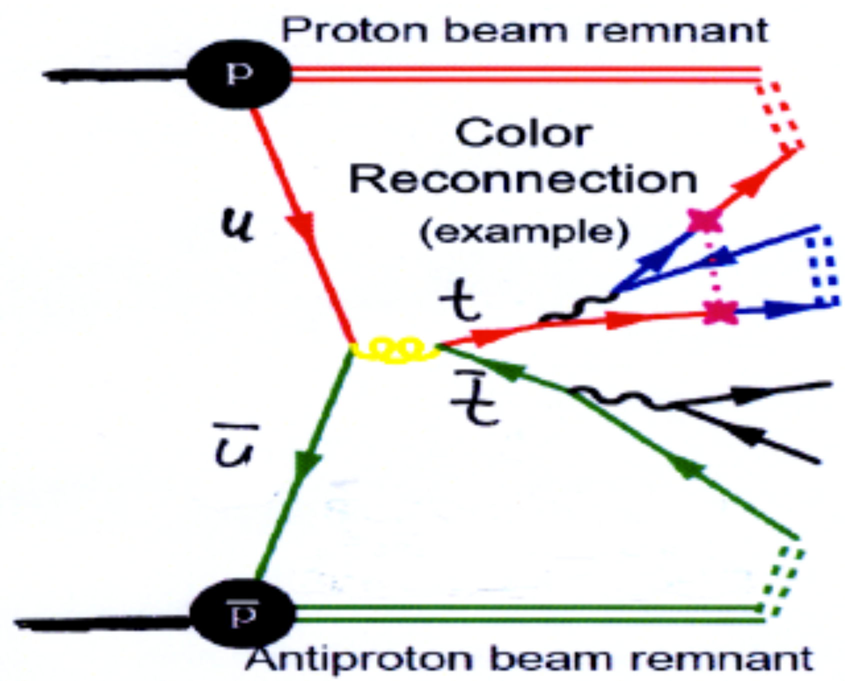
Forward-backward asymmetry: number of top and anti-top quarks moving for or against a given direction

For CP invariant system $N_{\bar{t}}(p)=N_t(\bar{p})$

$A_c = A_{fb}$

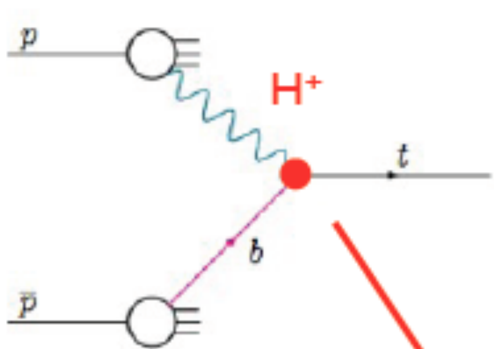
$$A_{fb} = \frac{N^{\Delta y>0} - N^{\Delta y<0}}{N^{\Delta y>0} + N^{\Delta y<0}}$$

Δy=y(top)-y(anti-top)

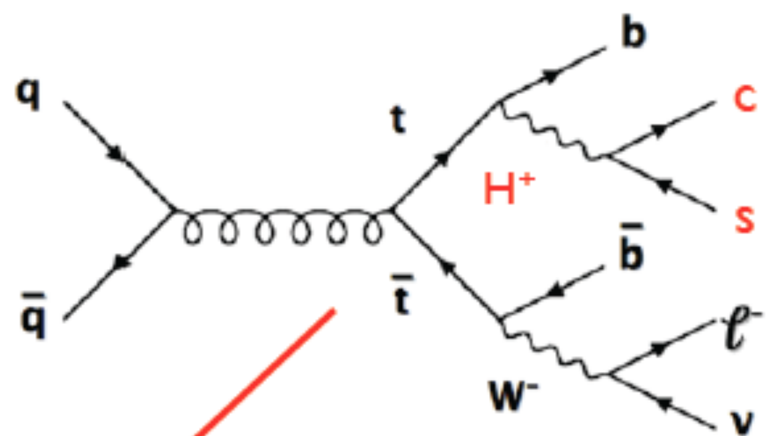

Proton beam remnant
p
Color
Reconnection
(example)
u
t
t̄
ū
p̄
Antiproton beam remnant

example: charged Higgs with $m_{H+} < m_t - m_b$

t-channel cross section



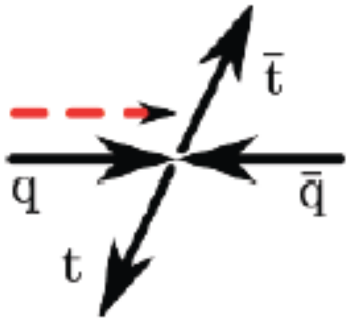
branching ratio $t \rightarrow Wb$



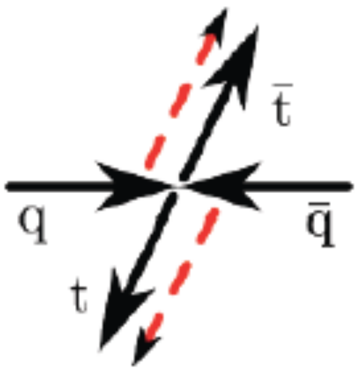
increase

$\neq 1$

$$\Gamma_t = \frac{\sigma(t\text{–channel})\ \Gamma(t \rightarrow Wb)_{\mathrm{SM}}}{\mathcal{B}(t \rightarrow Wb)\ \sigma(t\text{–channel})_{\mathrm{SM}}}$$

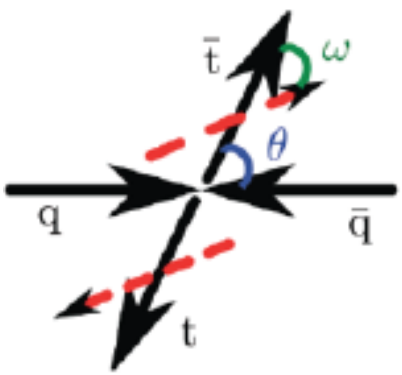


beamline: A = 0.777 at NLO
best for production at threshold



helicity: A = -0.352 at NLO
use direction of (anti)top quark in
$t\bar{t}$ rest frame to quantize the spin

Helicity angle: angle between decay product momentum in top rest frame and top quark momentum in $t\bar{t}$ rest frame



$$\tan\omega = \sqrt{1-\beta^2}\tan\theta$$

off-diagonal: A = 0.782 at MCNLO
good for pairs above threshold

Bernreuther, Brandenburger, Si and Uwer et al., Nucl. Phys. B 690, 81 (2004)

ME method details

Normalization acceptance & efficiency → $\frac{1}{\sigma(m_t)}$

Differential cross section based on LO ME → $d^n\sigma(y, m_t)$

$$P_{t\bar{t}}(x; m_t, JES) = \frac{1}{\sigma(m_t)} \int d^n\sigma(y, m_t)\, dq_1 dq_2 f(q_1) f(q_2)\, W(x, y, JES)$$

Probability to observe a set of kinematic variables x for a given mass and JES → $P_{t\bar{t}}(x; m_t, JES)$

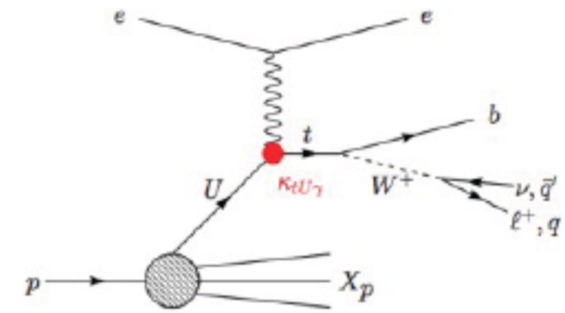
Initial state — Probability distribution that a parton will have a momentum q → $dq_1 dq_2 f(q_1) f(q_2)$

Transfer function — Probability to measure x when parton-level y was produced → $W(x, y, JES)$

- Integrate over unknown q_1, q_2, y
- The jet energy calibration (JES) is a free parameter in the fit, constrained in-situ by the mass of hadronically decaying W

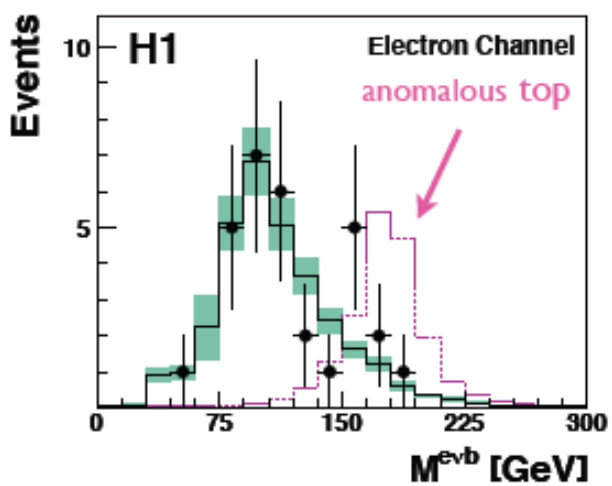
$$\mathcal{P}_{\text{event}}(x; m_t, \text{JES}) = f_t\, \mathcal{P}_{t\bar{t}}(x; m_t, \text{JES}) + (1 - f_t)\mathcal{P}_{bkg}(x, \text{JES})$$

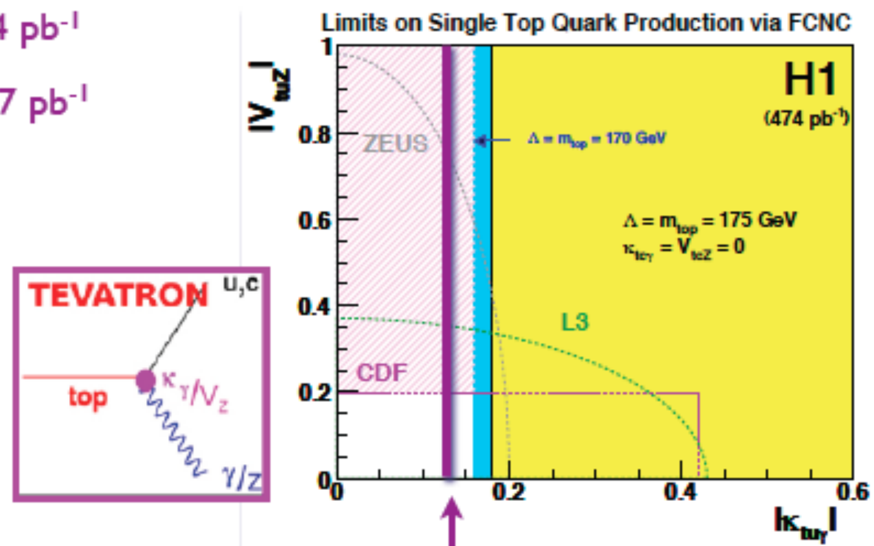
- Use the same selection as for W
- SM production is strongly suppressed
- Can be enhanced by FCNC
  - coupling of t to up-type quark U via γ or Z
- Background: single W production



$\sigma(ep\rightarrow etX)<0.25$ pb — H1, 474 pb^{-1}

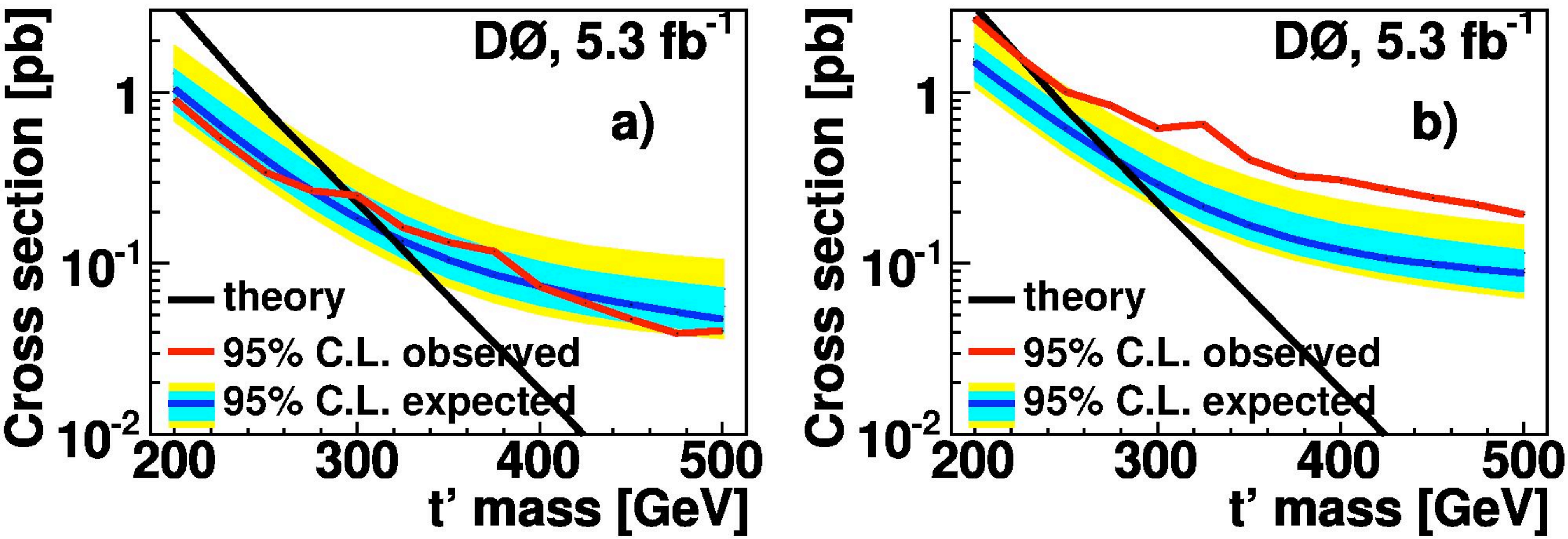
$\sigma(ep\rightarrow etX)<0.23$ pb — ZEUS, 277 pb^{-1}



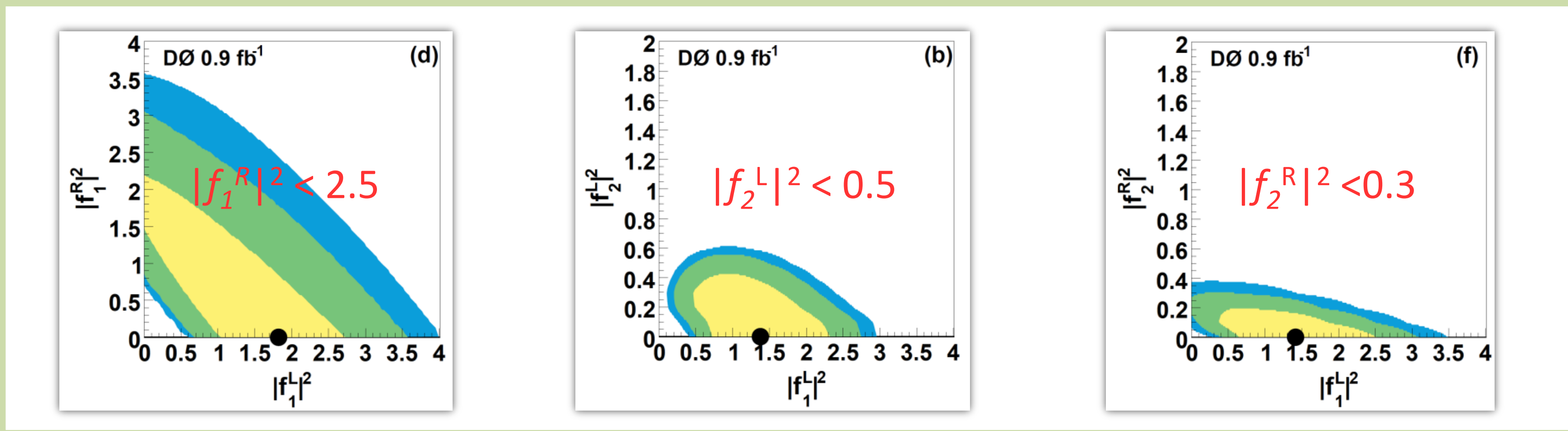


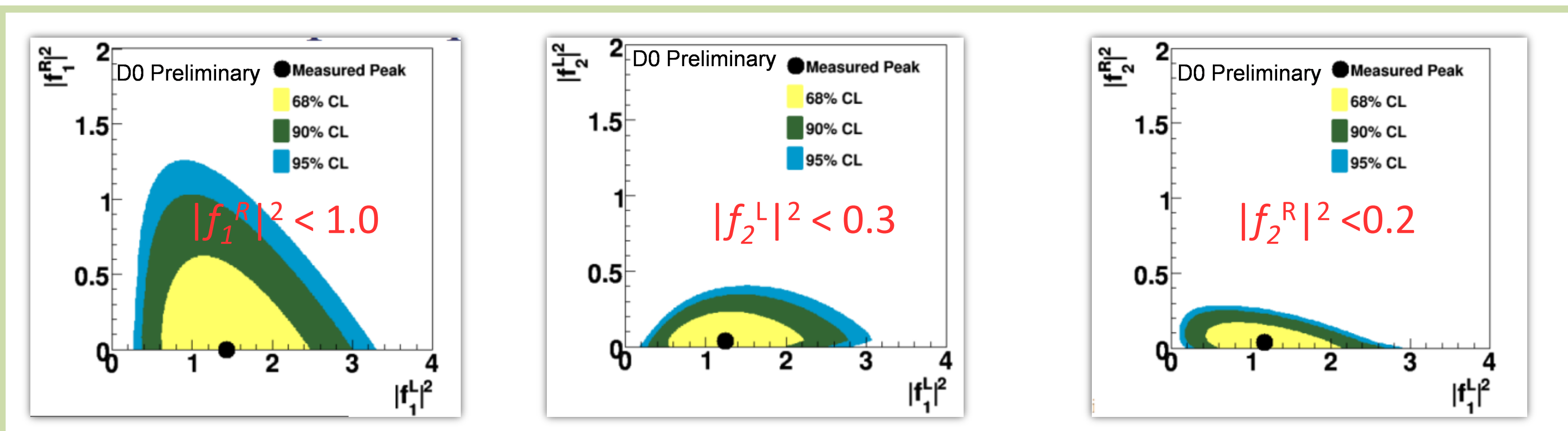
HERA I+HERAII, ZEUS, 359 pb^{-1}

$\sigma<0.13$ pb, $k_{tu\gamma}<0.13$


DØ, 5.3 fb^{-1}
a)
b)
theory
95% C.L. observed
95% C.L. expected
Cross section [pb]
t' mass [GeV]
1
10^{-1}
10^{-2}
200
300
400
500

W Helicity and Anomalous Couplings





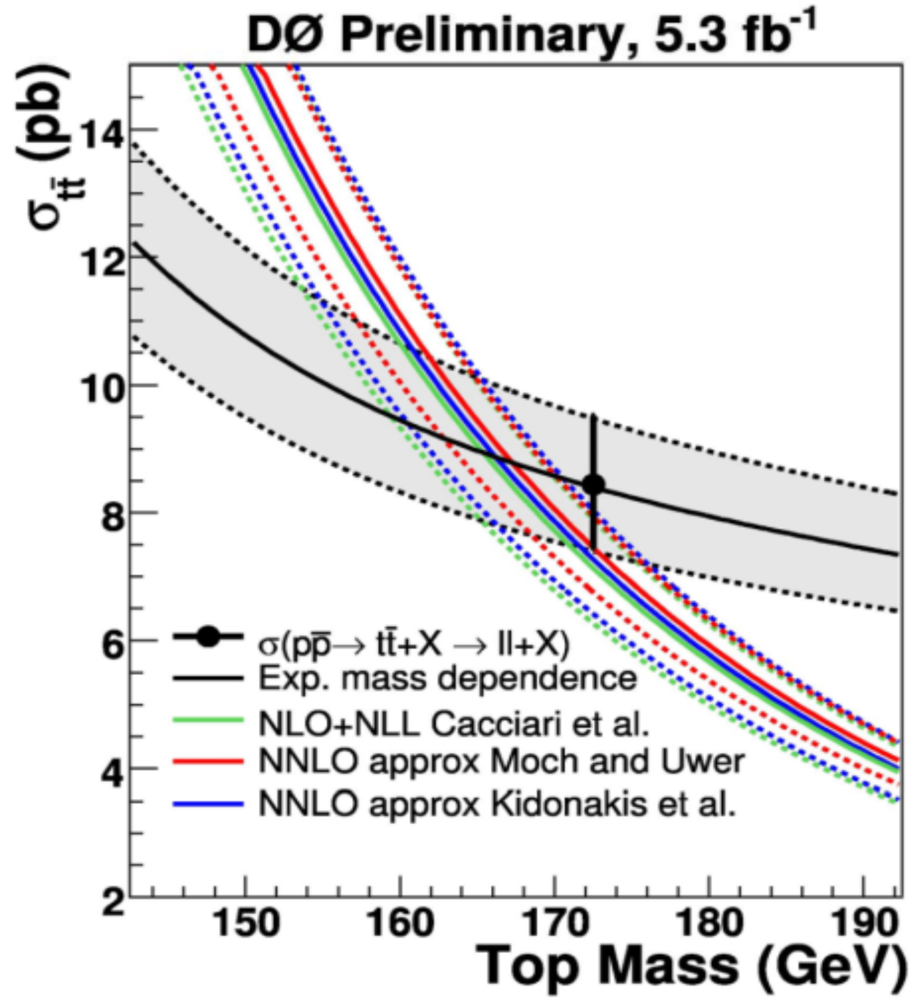
Top Quark Mass from Cross Section

- The Top quark cross section measurement allows for an indirect measurement of the top mass using the top-mass dependence of the cross section

- This dependence is different for different top mass schemes

  - so we can investigate these differences experimentally

Pole mass and MSbar mass can be onverted into one another



Top Quark Mass from Cross Section

- The experimental cross section is fitted as a function of the top quark mass

$$\sigma_{t\bar{t}}(m_t^{\mathrm{MC}}) = \frac{1}{(m_t^{\mathrm{MC}})^4}[a + b\,(m_t^{\mathrm{MC}} - m_0) + c\,(m_t^{\mathrm{MC}} - m_0)^2 + d\,(m_t^{\mathrm{MC}} - m_0)^3]$$

- A joint likelihood is calculated

  Gaussian uncertainties for experimental measurement

  Renormalization and factorization scale uncertainties on theory calculations are taken to be flat and changed from m_t to $m_t/2$ and $2m_t$

  PDF uncertainties are taken to be Gaussian

$$L(m_t) = \int f_{exp}(\sigma|m_t)(f_{\mathrm{scale}}(\sigma|m_t) \star f_{\mathrm{PDF}}(\sigma|m_t))d\sigma$$

- Input MC mass is assumed to be pole mass

  Measurement is repeated by assuming input MC mass is MS-bar mass instead

  Difference is taken as additional uncertainty