Search for anomalous couplings in top decay at Tevatron

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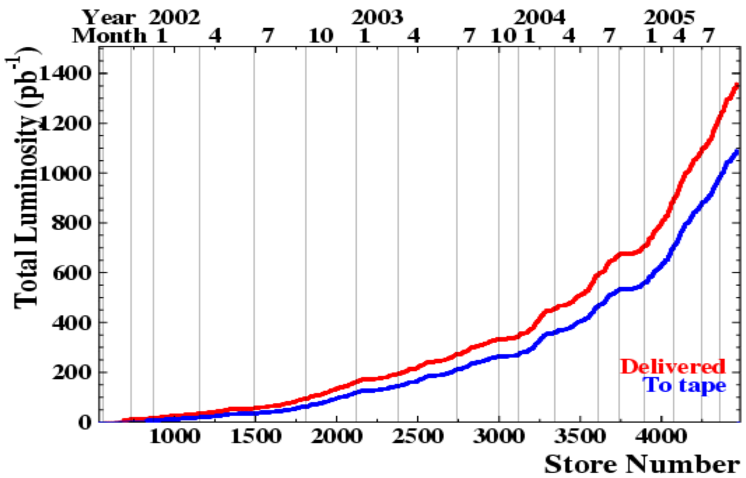
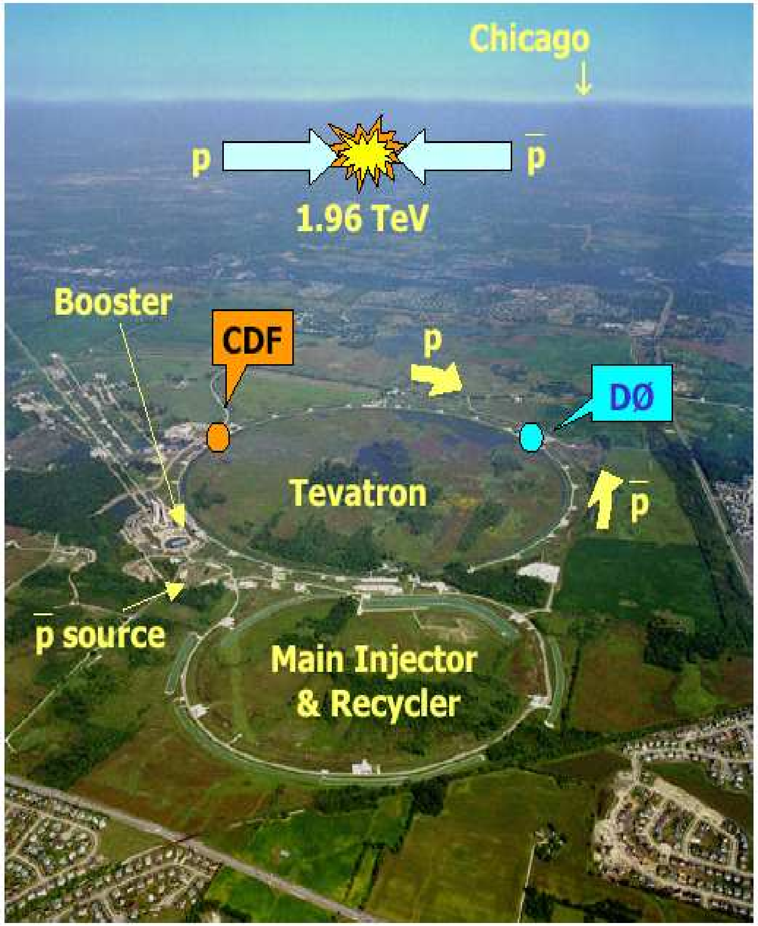
Contents / Highlights

- Tevatron / CDF II
- Top quark at CDF
- New reconstruction method of Top quark spin
- Search for anomalous couplings

The Tevaron Collider

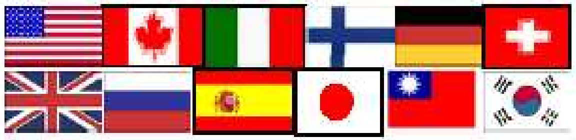
- Proton-antiproton collisions
  at 1.96 TeV (RunII) (1.8 TeV Run I)
- 36x36 bunch (396ns)
- ~1.1 fb^{-1} /exp. on tape. (20pb^{-1}/week)
- Record lum. ~$1.7x10^{32}cm^{-2}s^{-1}$
- Main Injector: 150 GeV proton storage ring
- Recycler: used as the antiproton storage ring.
  Electron cooling was established.





Tevatron is working well on the design luminosity!!
expected ~ 8 fb^{-1} in 2009.

Tevatron Experiments



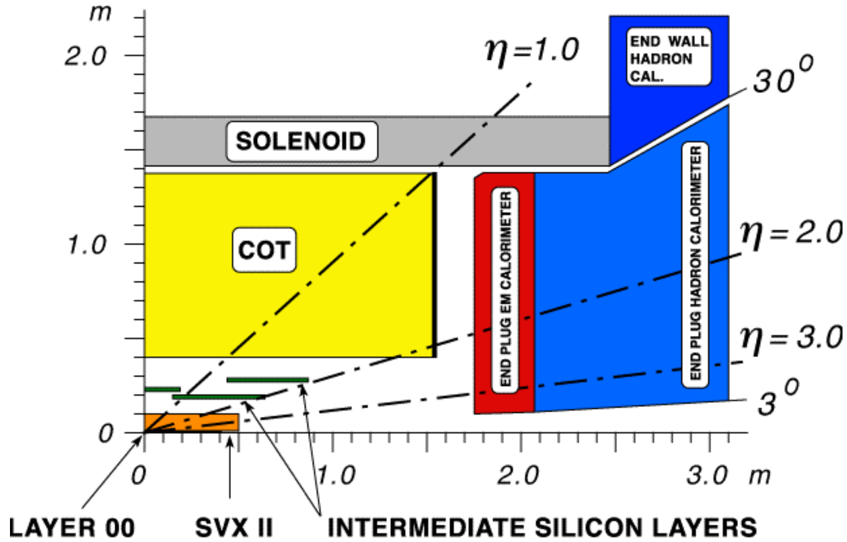
13 countries, 58 institutions
798 physicists

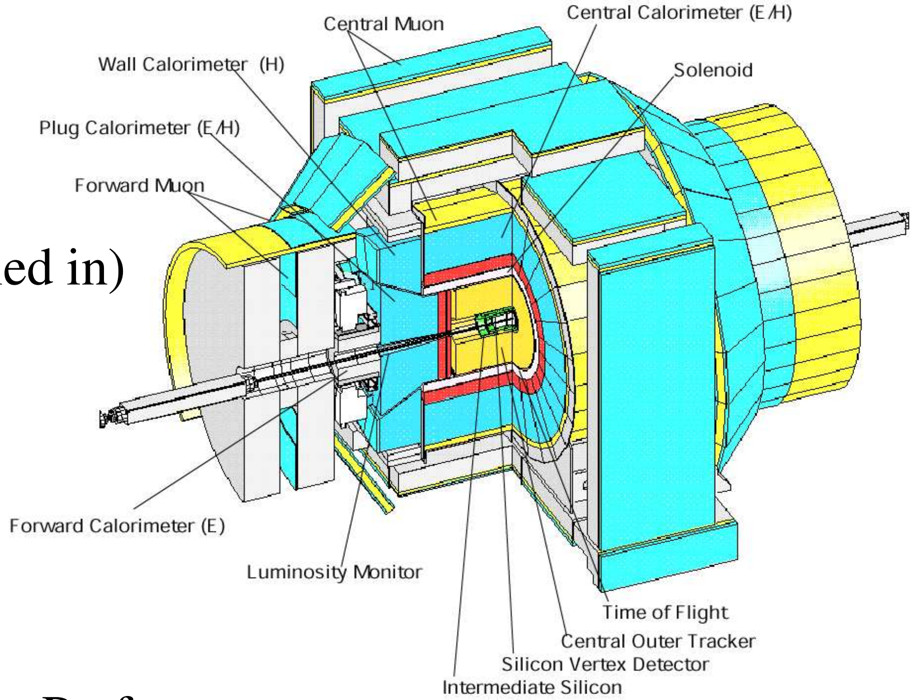
19 countries, 83 institutions
664 physicists

The CDF Run II detector

Fully upgraded detectors:

- Silicon, COT
- Plug calorimeters
- Extended Muon coverage (gaps filled in)
- DAQ & L2 triggers

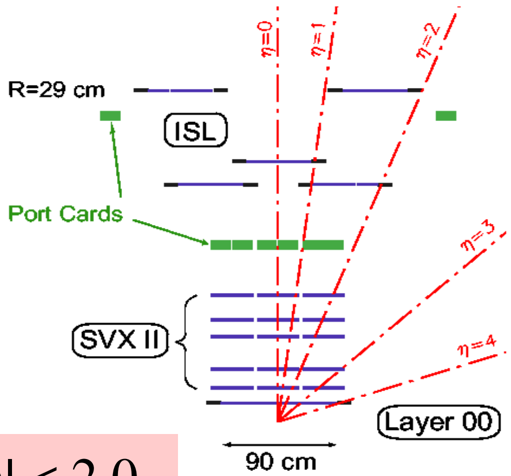




Performance:

- EM: $\sigma_E/E \sim 14\% /\sqrt{E_T}$
- HAD: $\sigma_E/E \sim 80\% /\sqrt{E_T}$
- Trk: $\sigma(d0) \sim 40\ \mu m$ (incl. 30μm beam)
  $\sigma(p_T)/ p_T \sim 0.15\%\ p_T$
- Silicon B-tagging ~ 60% for top events

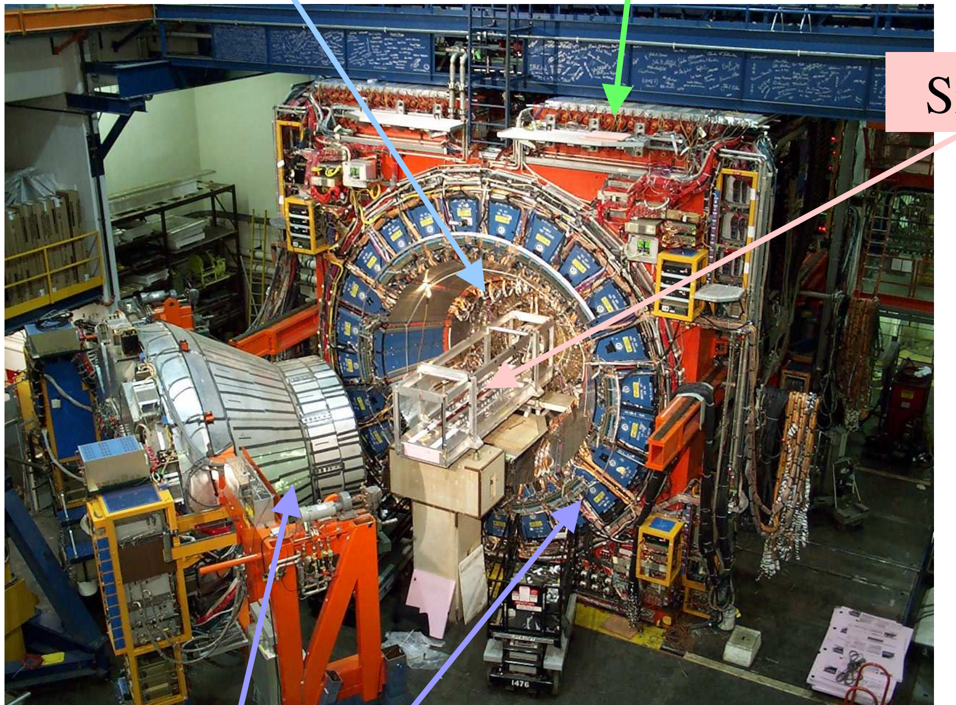
CDF Run II detector

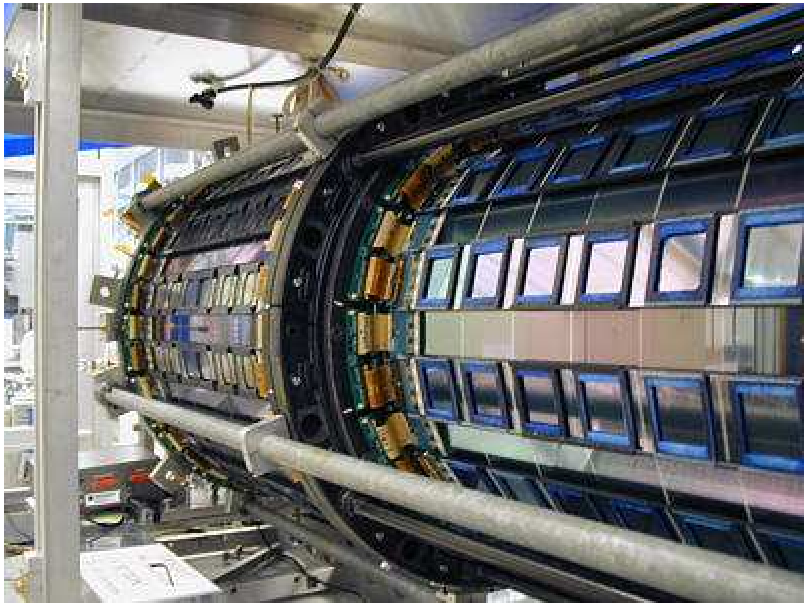


Central tracker |η| < 1.0

Muon Chambers |η| < 1.5

Silicon tracker |η| < 2.0

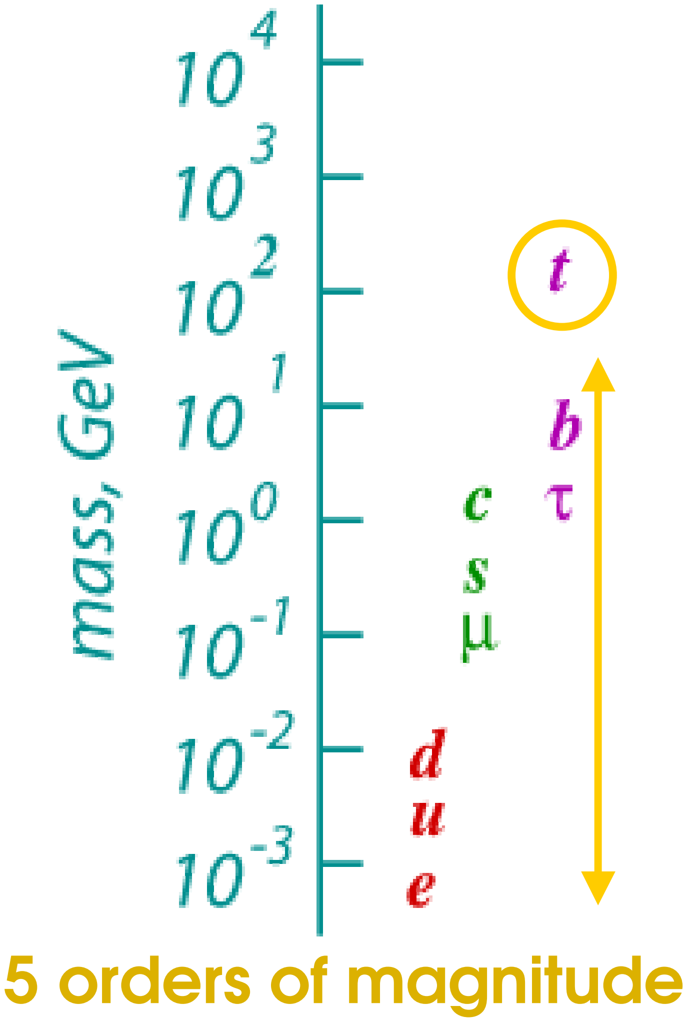


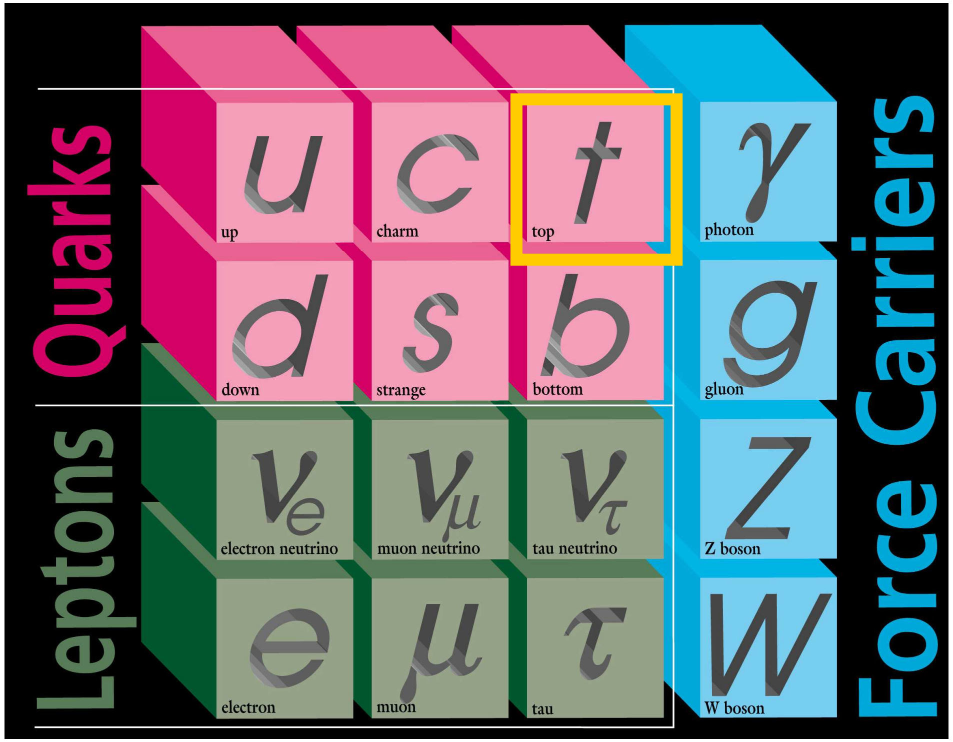


Plug+Central Calorimetery |η| < 3.6

The top quark

Top quark was discovered at Tevatron Run I on 1995.





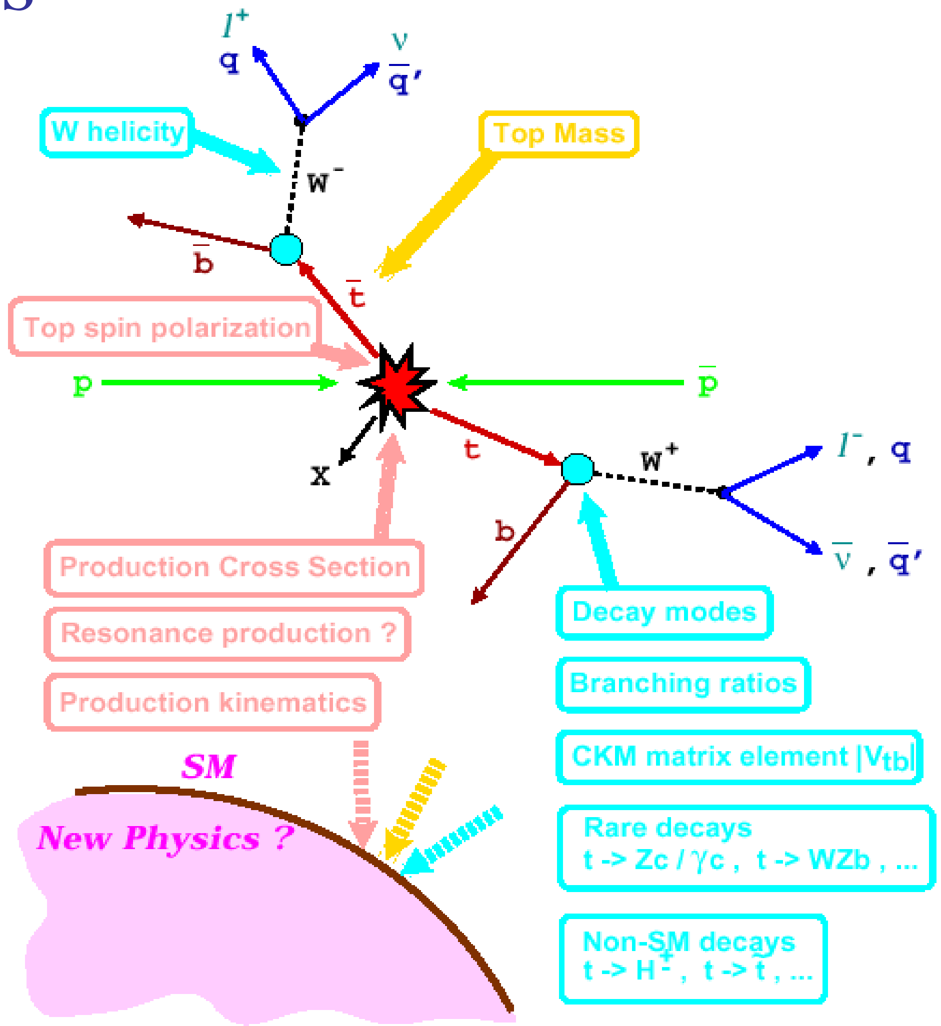
Top Quark Physics

Major analysis groups:

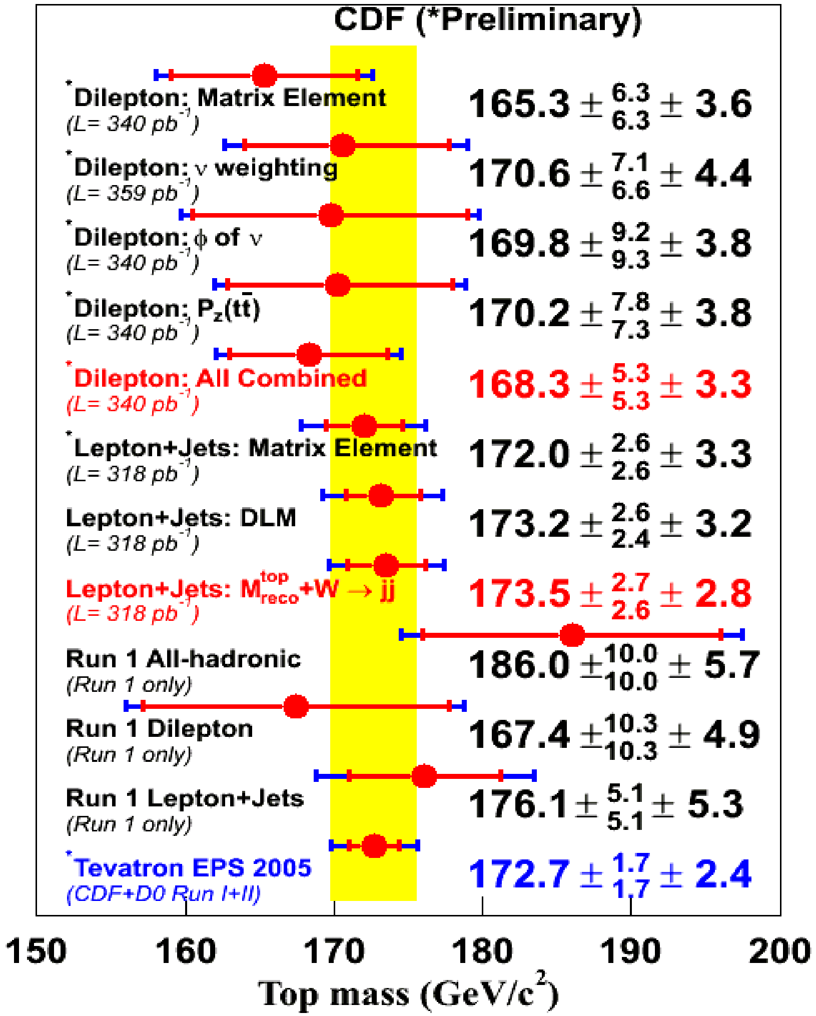
- Cross section
- Mass
- Top property
  - Decay property
  - Production mechanics
- Single top

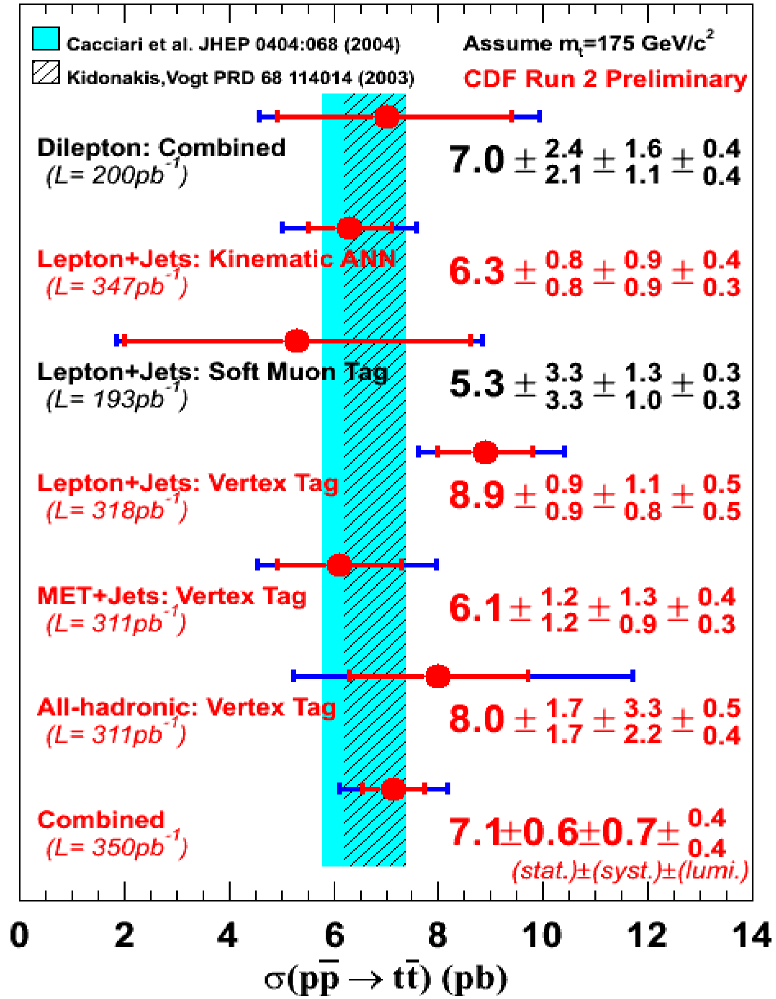
Sub groups:

- Lepton ID
- B-tagging
- Jet Energy Correction
- Background studies



Top mass & cross section at Run II





Top Quark today

Run I (1.8 TeV)			Run II (1.96 TeV)	
	Observation 1995	In the end of Run I	2005.3	2006.3
	$67pb^{-1}$	$106pb^{-1}$	$318pb^{-1}$	$\sim 1fb^{-1}$
Top candidates Tagged events		~30 events	~100 events	~300 events

We are here.

Note these number of events are of course very different in each measurements.

The study of top property is the most interesting topics!

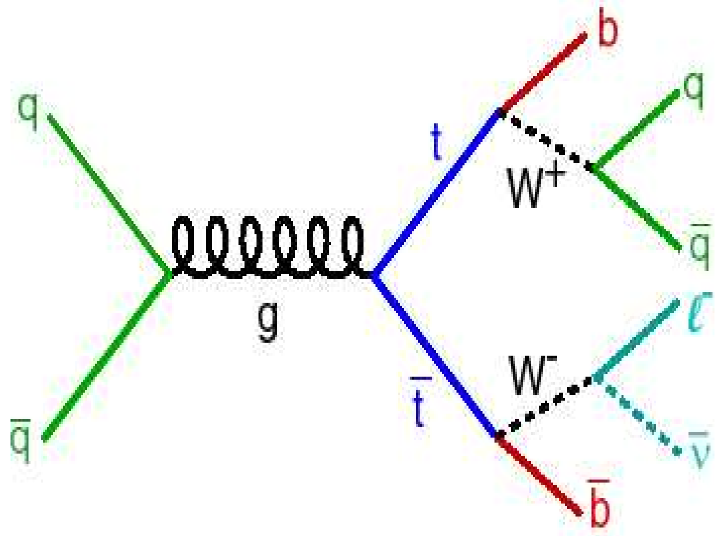
Production and decay

Typically, pair-production :

σ = 6.7 pb (m_t = 175 GeV)

via $q\bar{q}$ (85%) and gg (15%).

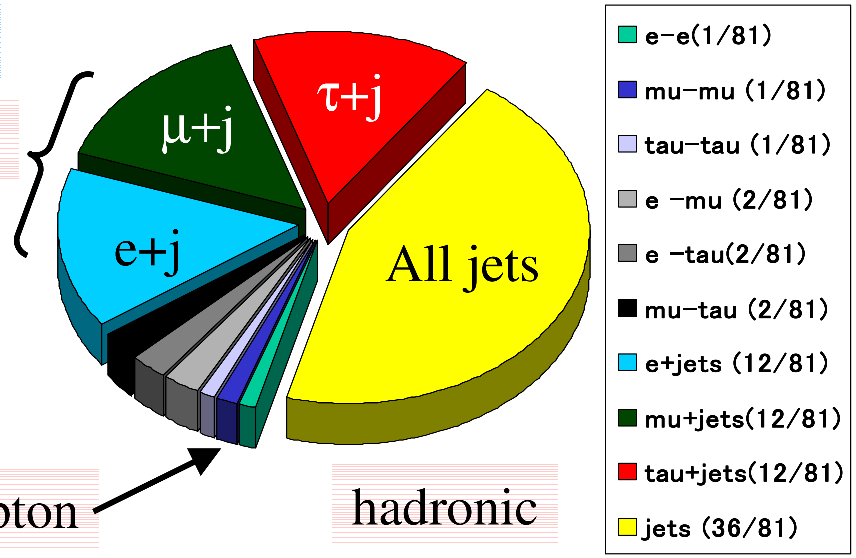
Decay : Br(t   Wb) = 100 %



The analysis channels rely on W decay.

Lepton+jets

All hadronic	:	~ 45 %
Lepton (e,μ) + Jets	:	~ 30 %
Dilepton (e,μ)	:	~ 5 %



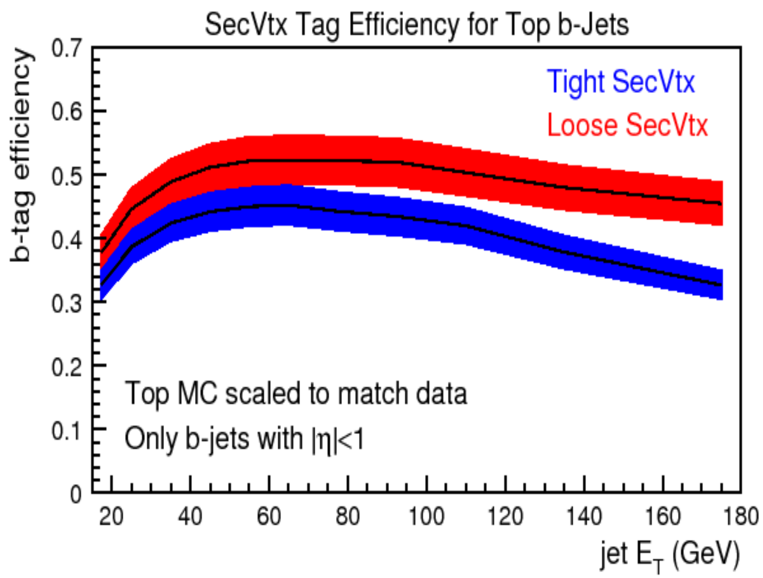
Identifying the Top Quark (I)

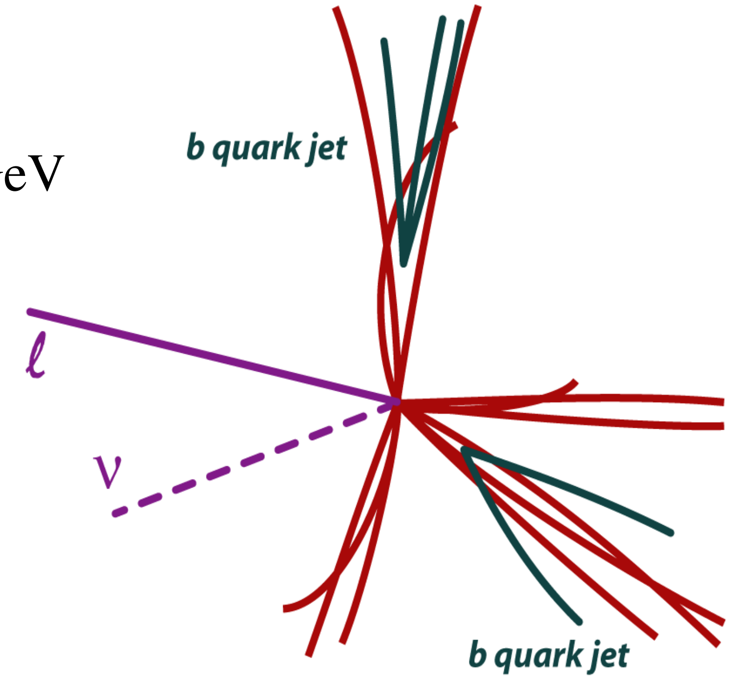
Lepton + jets channel :

- Isolated leptons is identified with $p_T > 20$ GeV
- Large missing $E_T > 20$ GeV
- 4 leading jets with (typically $E_T > 15$ GeV)
- b-tagging is a crucial to avoid QCD bkg.

b-quark lifetime : $c\tau \sim 450\ \mu m$

B-hadron travels ~ 3 mm





We use Secondary Vertex tagger as the default.

Achieved 55 % tagging efficiency

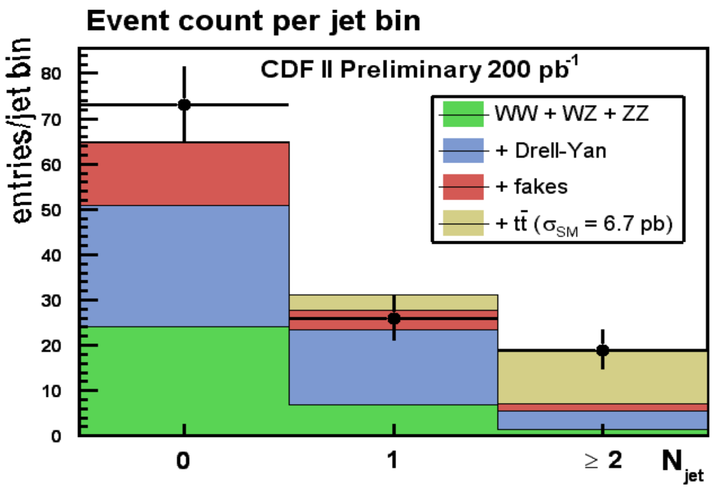
0.5 % mistagged rate (per jet)

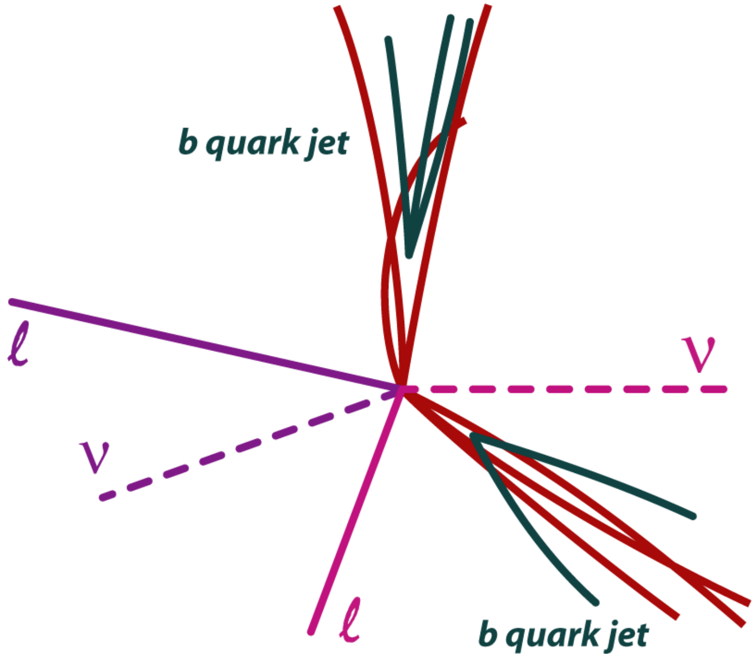
for tt MC sample.

Identifying the Top Quark (II)

Dilepton channel :

- 2 high p_T leptons with p_T > 20 GeV one must be isolated.
- Large missing E_T > 25 GeV
- Scalar Sum E_T (H_T) > 200 GeV
- Rather than requiring b-tagging to avoide QCD bkg., loose lepton ID to obtain the statistics.





Backgrounds are mostly:

- Drell-Yan
- Diboson productions
- Fake leptons

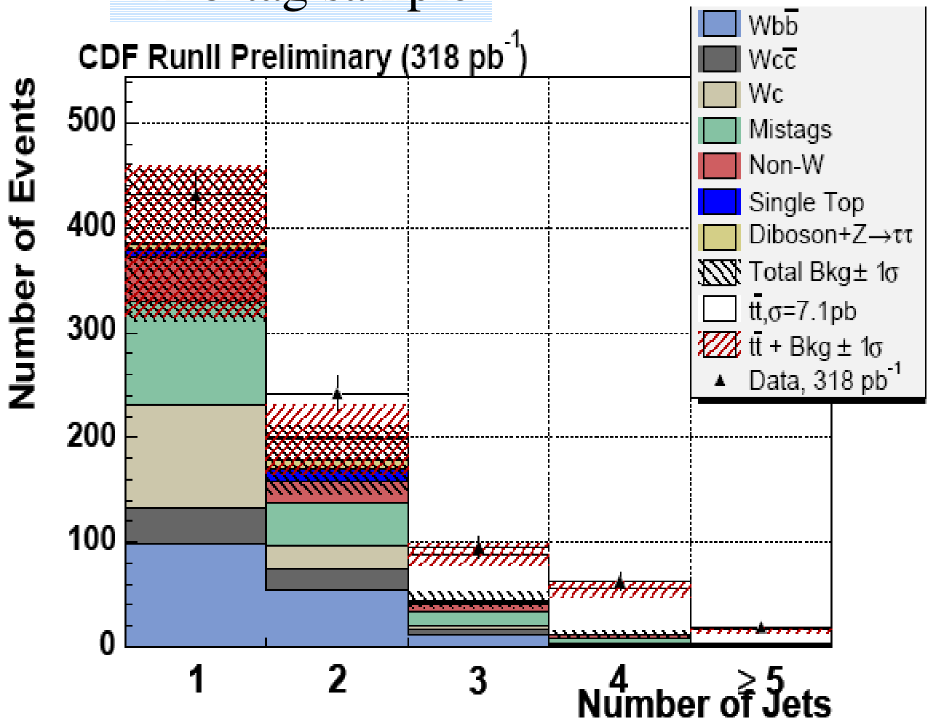
Background estimates

Conceptual idea :

The top signal is presumably multi-jet final state.

- W +heavy flavor jets(bb,cc,c)
  - Heavy flavor fraction from MC
  - Normalized to data
- W+jets(mistag)
  - Use measured mistag rate, applied to the data
- Multijet:fake-W (jet e, track μ)
  - Estimated from data
  - Iso. v.s. Missing E_T
- Others (single top, dibson (WW,WZ))
  - Estimated from MC

≥1 b-tag sample



Controlled region

Signal region

Jet Energy Scale is the most dominant source of systematics.

Monte Carlo Event Generators

- Signal MC
  - depending on the physics analysis. (ex. xsec:PYTHIA, mass:HERWIG)
  - acceptance calc., shape parameterization
  - even in the likelihood fitter (ME-based fitter), MC generators are used.
- Background MC
  - need group consensus … default MC is AlpGen in CDF.
  - acceptance calc., shape parameterization

Updated: September 12, 2005

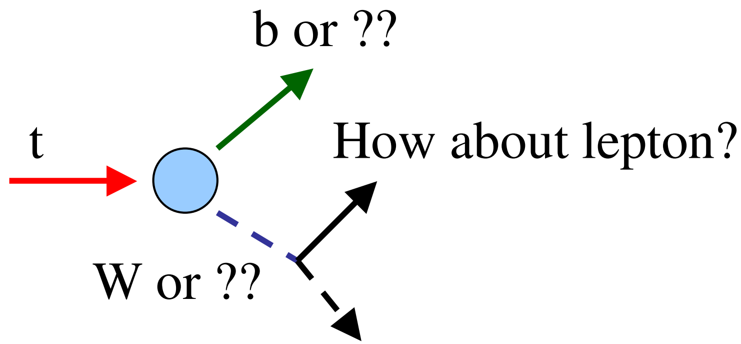
X-sects (pb)	Number of jets						
$e^-e^+ + n$ QCD jets	0	1	2	3	4	5	6
ALPGEN	723.4(9)	188.3(3)	69.9(3)	27.2(1)	10.95(5)	4.6(1)	1.85(1)
AMEGIC++/SHERPA	723.1(7)	188.2(3)	69.7(2)	27.3(1)			
CompHEP	730.9(1)	190.20(7)	70.22(7)				
GR@PPA	724.2(8)	188.4(3)	69.62(8)	26.68(5)	11.02(3)		
HELAC/PHEGAS/JetI	744(7)	187(1)	70.9(4)	28.2(4)			
MadEvent	723(1)	188.6(4)	69.3(1)	27.1(2)	10.6(1)		

Top Quark property measurements

Public results : http://www-cdf.fnal.gov/physics/new/top/top.html

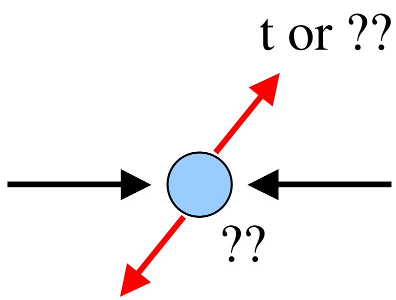
Using ratio :

- Br(t Wb) / Br(t Wq)
- Br(t H^+b)
- Br(t $\tau W)_{obs}$ / Br(t $\tau W)_{SM}$
- σ(dilepton) / σ(lep + jets)



Using kinematics :

- W helicity measurements (p_T & $\cos\theta$)
- Anomalous kinematics in dilepton channel
- t’ (forth generation) search
- tt resonance



- Single top
- heavy flavor fraction in W+jets

Other on-going studies :

- Top charge, qq/gg, FCNC, spin correlation, asymmetry.

Br(t   Wb)/Br(t   Wq)

Is the Br(t   Wb) really 100% ??

$$R \equiv \frac{BR(t \to Wb)}{BR(t \to Wq)} = \frac{|V_{tb}|^2}{|V_{td}|^2 + |V_{ts}|^2 + |V_{tb}|^2}$$

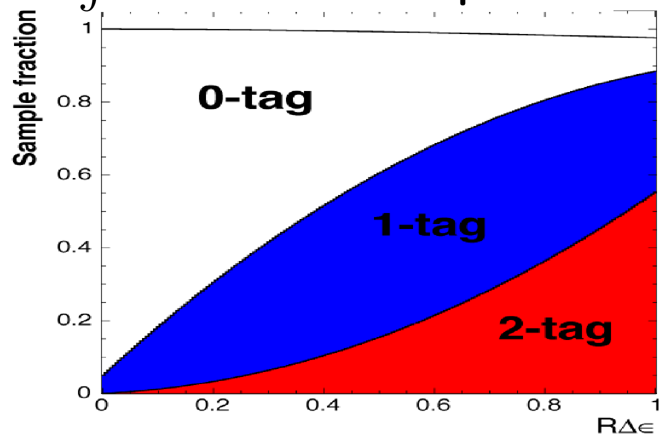
Compare the expected top with the observed top in the 0/1/2 tag subsets and extract R by maximizing the likelihood.

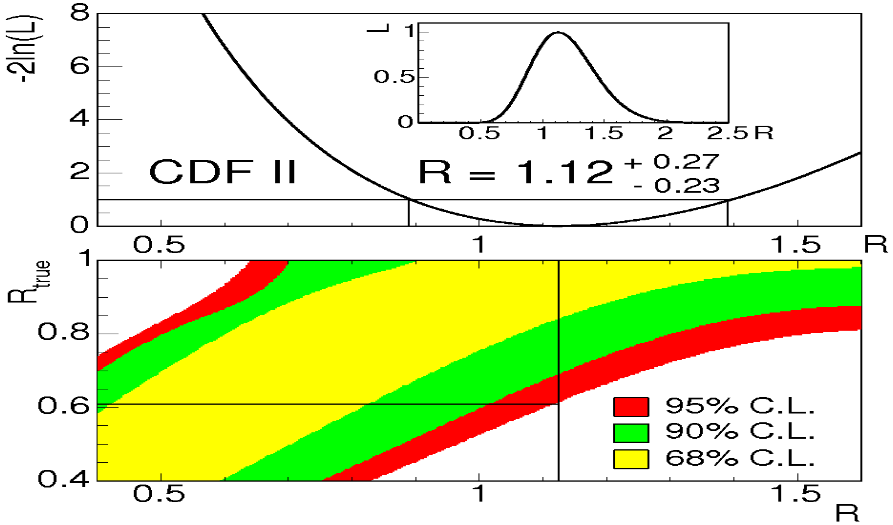
With no bkg.

$$\mathcal{R} \cdot \epsilon_b = \frac{2}{N_1/N_2+2} = \frac{1}{2N_0/N_1+1} = \frac{1}{\sqrt{N_0/N_2}+1}$$

ε_b is measured separately (~40% for CDF).

$\int \mathcal{L} dt = 162 pb^{-1}$





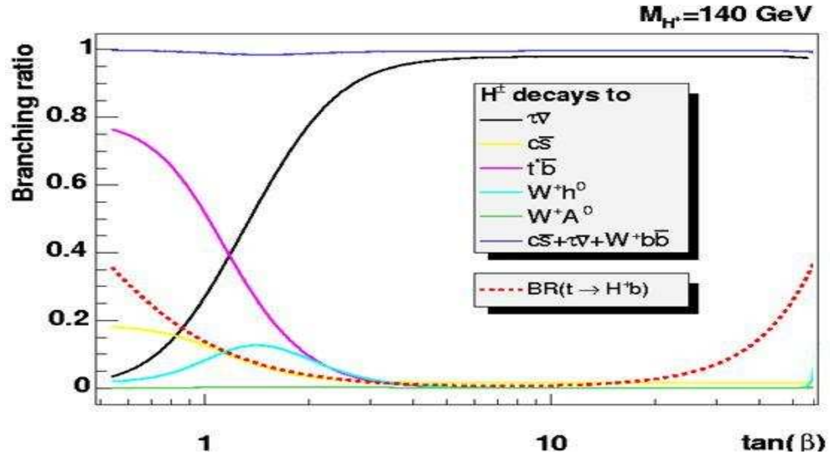
R >0.61 at 95% CL

|Vtb| > 0.79 at 95% CL

Charged Higgs Br(t H^+b)

Assume each top quark has
5 possible decay modes

- $t \rightarrow Wb$
- $t \rightarrow H^+b \rightarrow t^*bb \rightarrow W^+bbb$
- $t \rightarrow H^+b \rightarrow \tau\nu b$
- $t \rightarrow H^+b \rightarrow csb$
- $t \rightarrow H^+b \rightarrow W^+h^0b \rightarrow W^+bbb$



Put them into likelihood function.

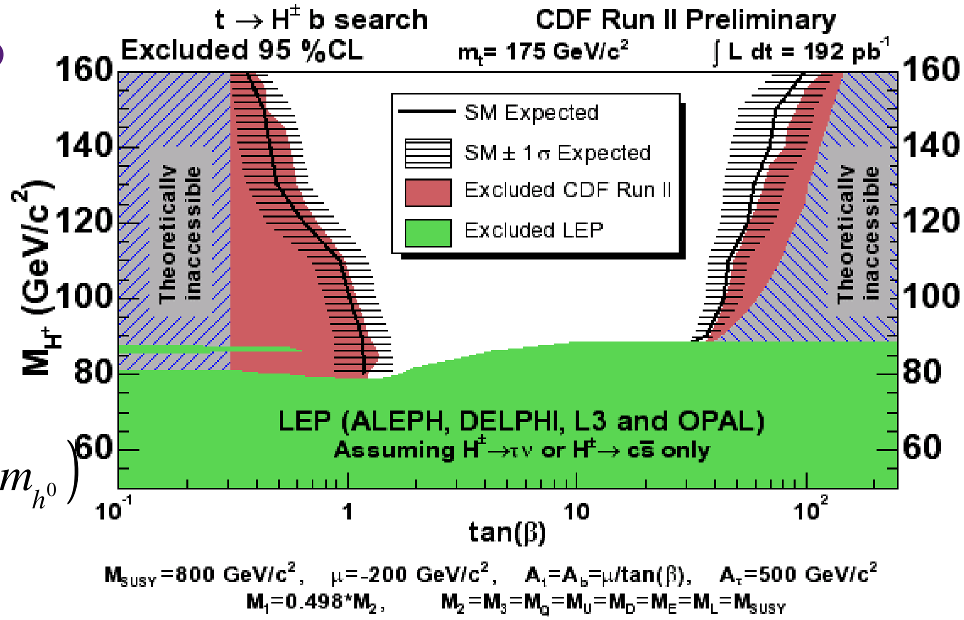
$$N_{XSA}^{\exp} = N_{XSA}^{back} + \sigma\, \varepsilon_{tt,XSA} \int Ldt$$

where,

$$\varepsilon_{tt,XSA} = \sum_{i,j=1}^{5} B_i B_j \;\; \varepsilon_{i,j\ \mathrm{XSA}}\left(wTop, wHiggs, m_{H^\pm}, m_{h^0}\right)$$

from MC

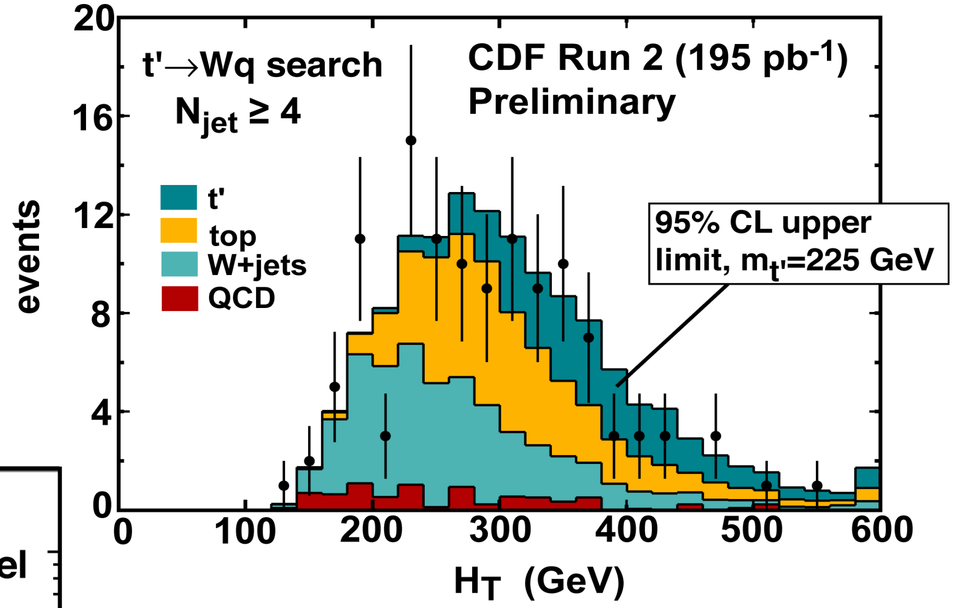
Br. for i-tth

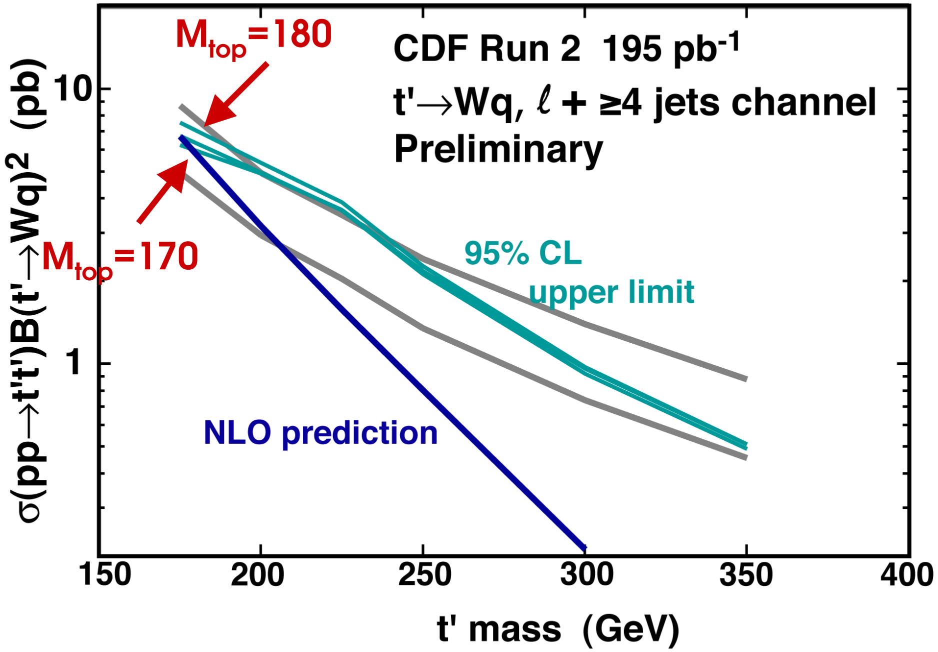


Forth generation heavy quark search

H_T (scalar sum) is a strong discriminator for heavier particles than top quark.

Limits on σ x BR(t'→Wq)^2





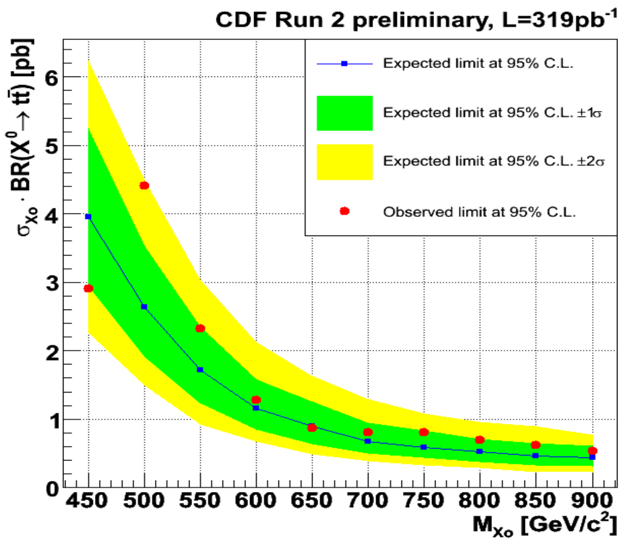
Top production cross section is constrained (with different mass range).

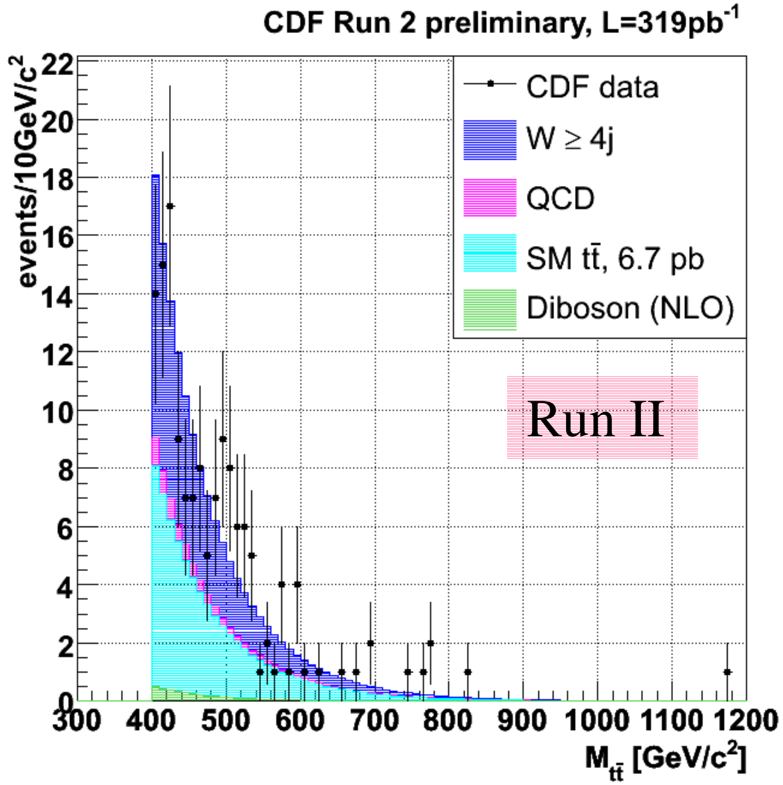
→ Less dependence.

Search for $t\bar{t}$ resonance

New

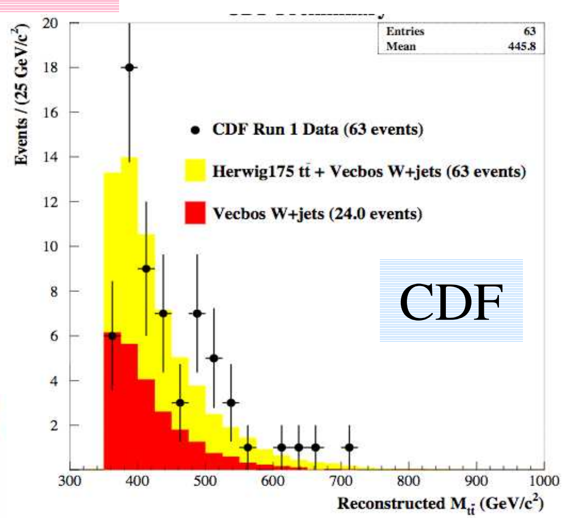
- Lepton + jets channel is used.
- Different analysis procedure from Run I.
- Joint likelihood based on ME weighted technique is used.
  - Average over parton-jet assignments

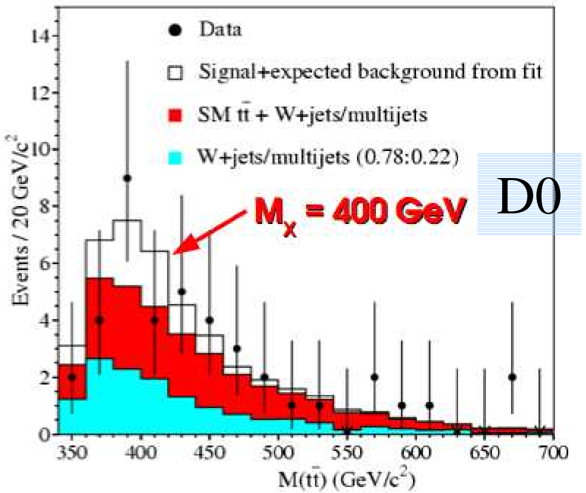




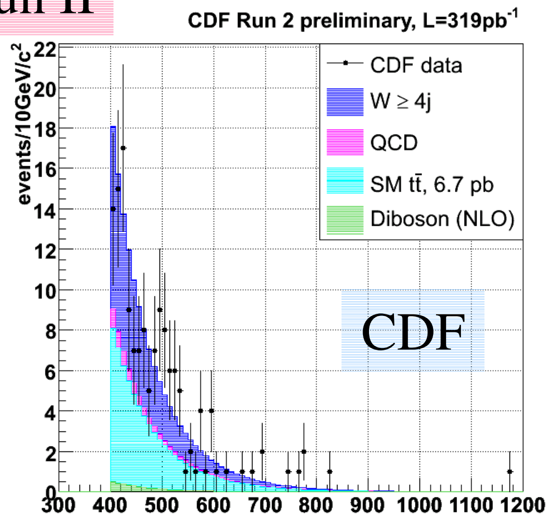
From CDF and D0

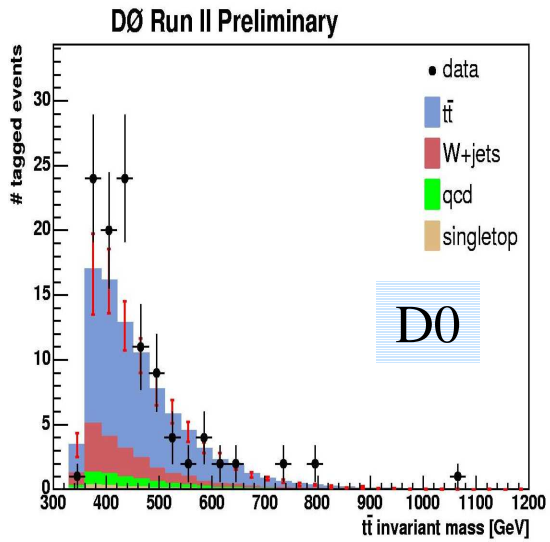
Run I



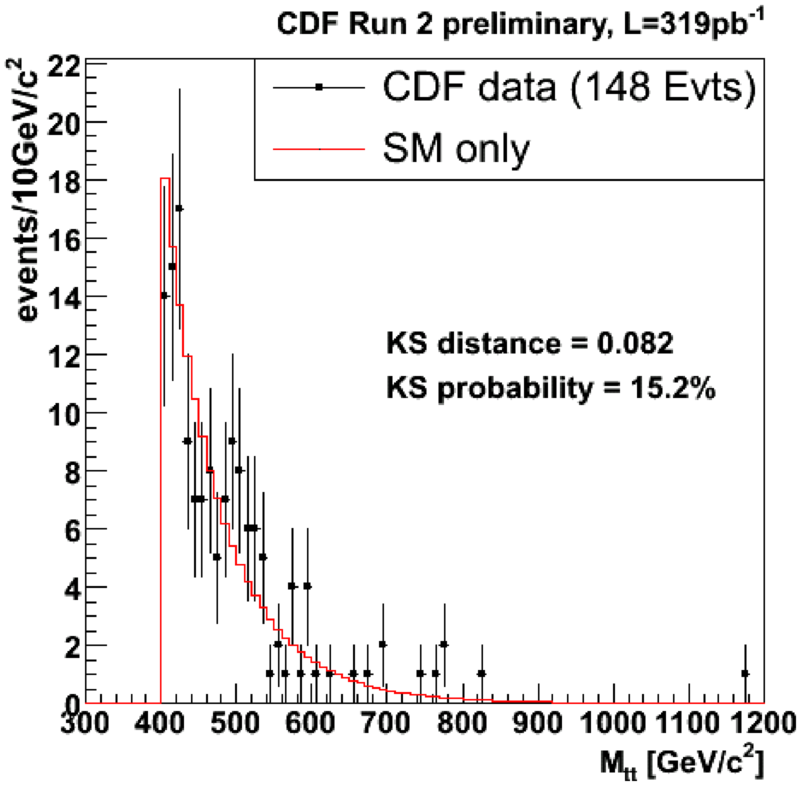


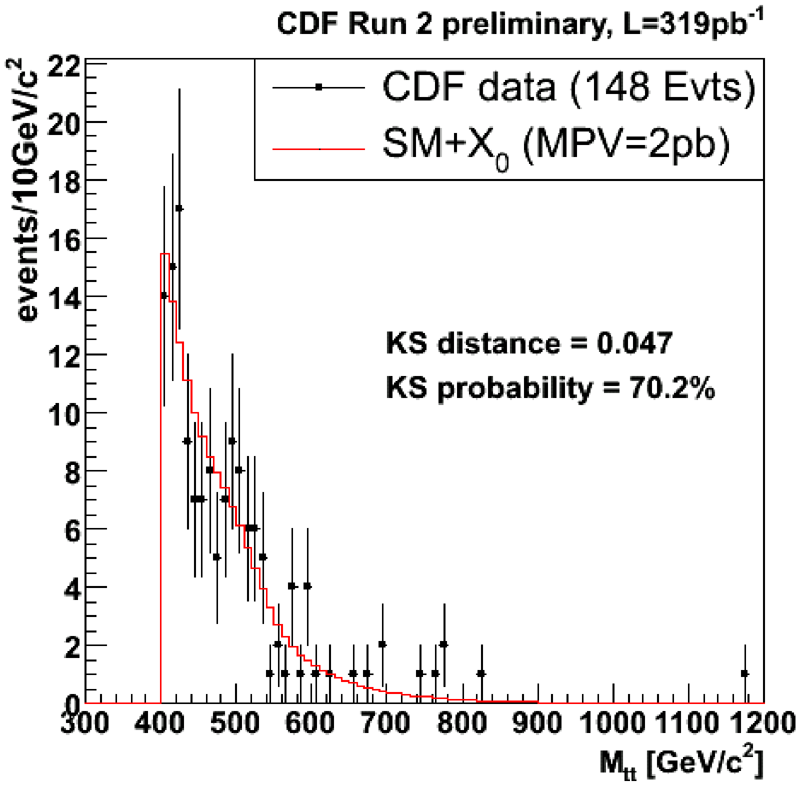
Run II





Test of the SM





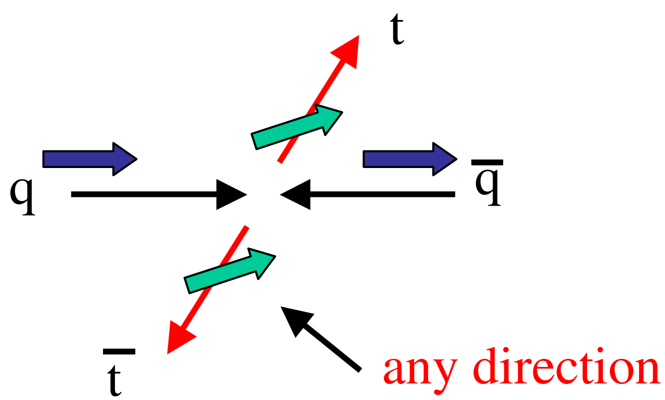
Needs more data to judge this…

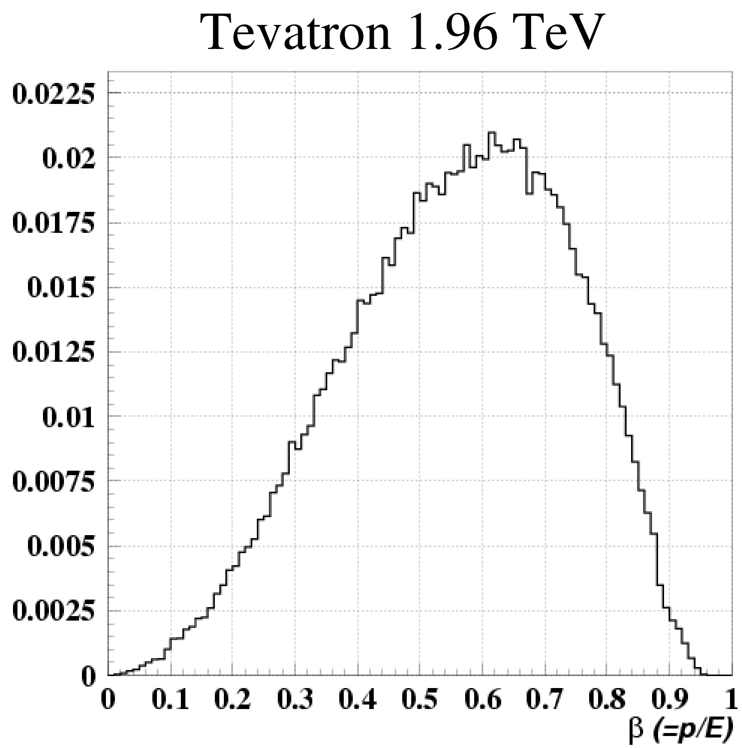
A new method for Top Spin Reconstruction

S. Tsuno (Okayama Univ.)
Y. Sumino (Tohoku Univ.)

Top Quark Spin

In $q\bar{q}$ collision, the two top quark spins have the same direction.
(propagate via gloun)





However, the top quark has mass (175 GeV) and finite p (~100 GeV).
At Tevatron, the $\beta \sim 0.6$.

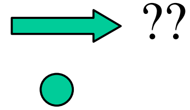
The top quarks are produced as "unpolarized" state at tree level.
(but both same directions.) At NLO, ~0.5 % effect.

Top Spin correlation

The "unpolarized" means "no direction".

→ Using only top side, how should we define the direction?

Umm…

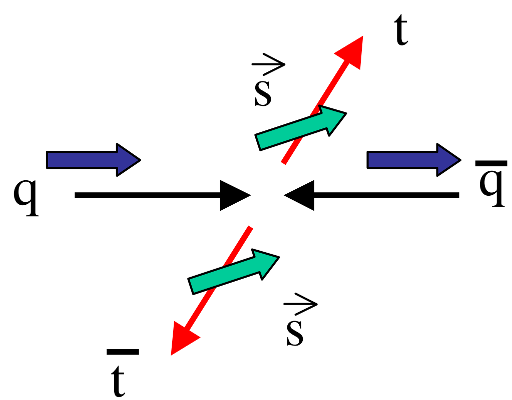


top rest frame

In order to define(fix) the spin direction, we use the other side top quark information.

Top antitop spin correlation

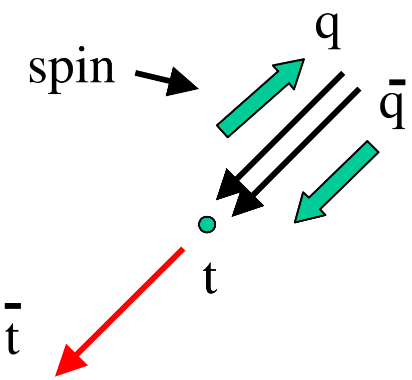
$$\vec{S}_t \cdot \vec{S}_{\bar{t}} = -1$$



Spin basis

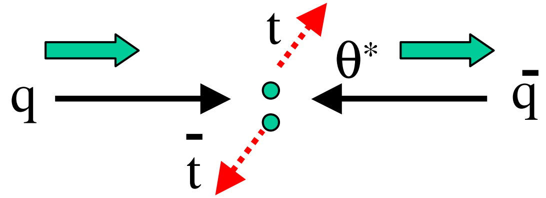
Helicity basis : $\vec{s}_t \cdot \vec{p}(t)$ (top direction)

- defined in the ultra relativistic limit.
- valid for large p .



Beamline basis : $\vec{s}_t \cdot p_Z(beam)$

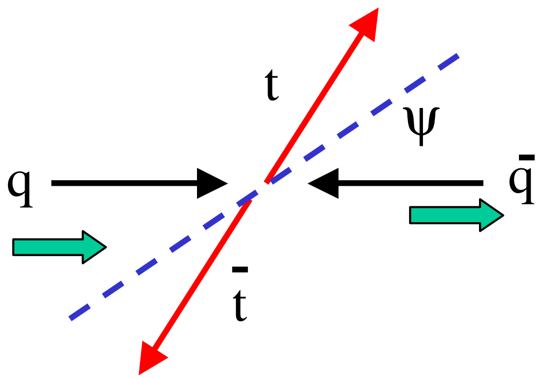
- defined in zero momentum frame.
- only valid for qq initial state.



Off-diagonal basis :

$$\vec{s}_t \cdot \tan\psi = \vec{s}_t \cdot \frac{\beta^2 \cos\theta^* \sin\theta^*}{1-\beta^2 \sin^2\theta^*}$$

- correct basis including top momentum.
- only valid for qq initial state.



Note that in LHC, helicity basis is only available.

One more correlation

The top can immediately decay into blν without any hadronization.

The spin information is transferred into final state particles.

Decay correlation :

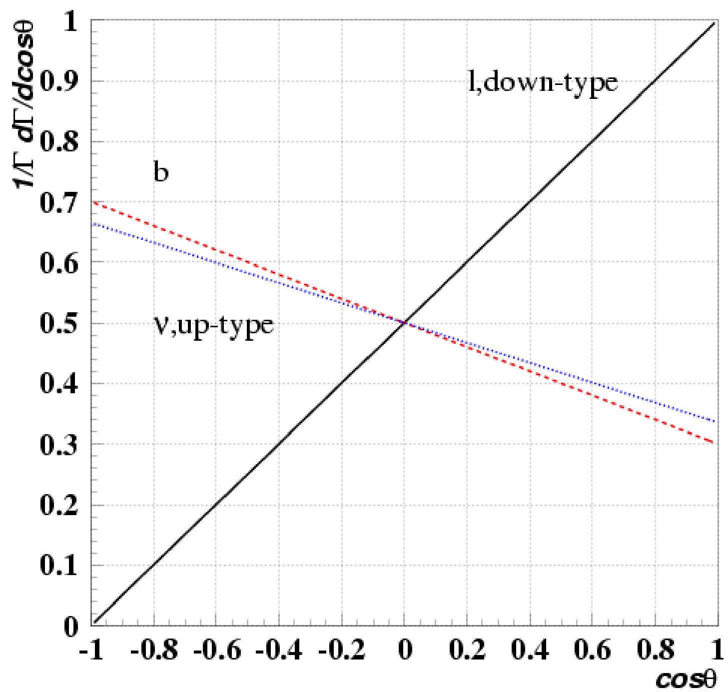
$$\frac{1}{\Gamma}\frac{d\Gamma}{d(\cos\theta_i)} = \frac{1}{2}(1+\alpha_i\cos\theta_i)$$

where, i is decay products.

Correlation coefficients α s :

b	-0.40
ν, up-type q	-0.33
l, down-type	1.0

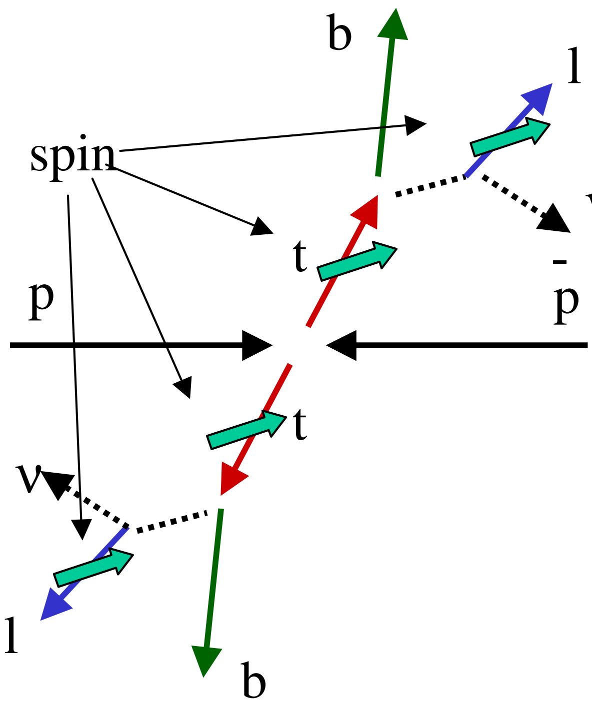
At mt=173 GeV, mw=80 GeV



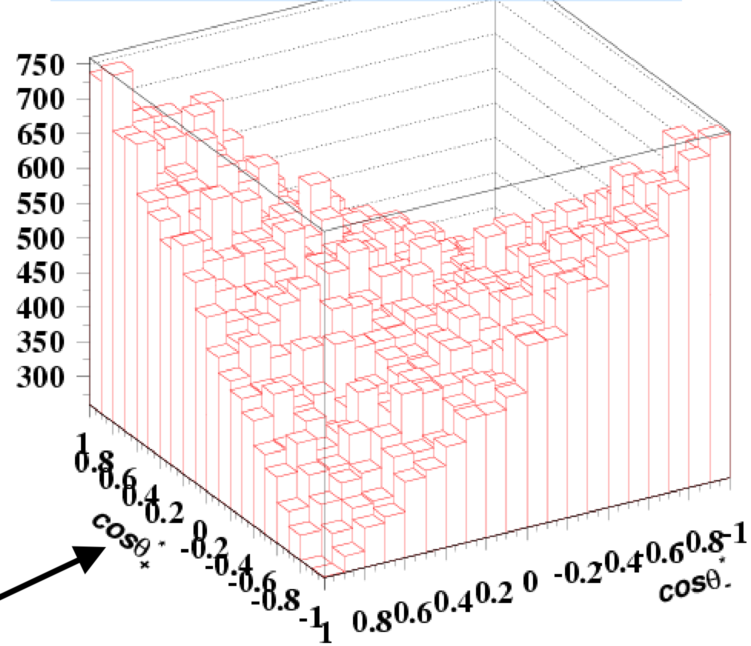
Lepton is a strong spin analyzer.

Conventional analysis

Using two step spin correlations,



Top antitop spin correlation



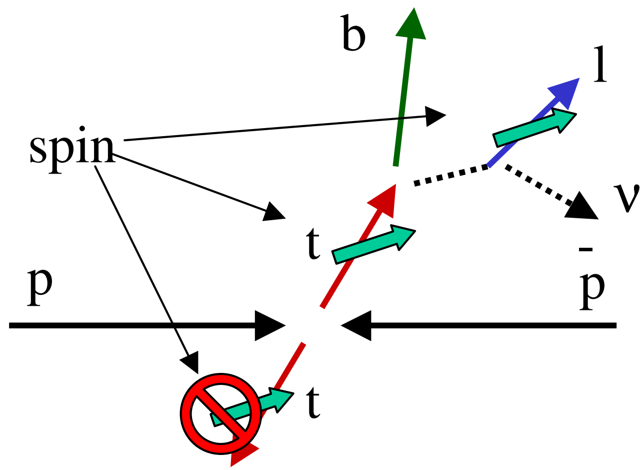
Angle between lepton and spin basis.

$$\vec{s}_t \cdot \vec{s}_{\bar{t}} = -1$$

Effective Spin Reconstruction (I)

New

Use only top side.



Lepton flight direction fully correlate with top quark spin.

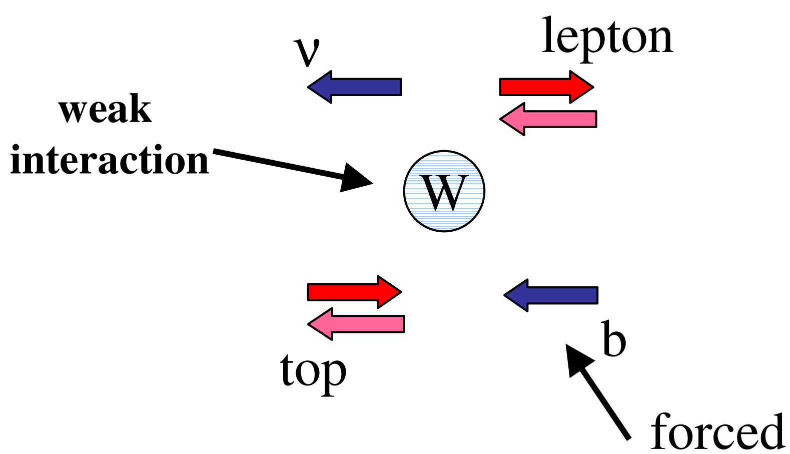
Only allowed two configuration if b and ν are massless.

Wave function may be something like

$$\begin{pmatrix} |+\rangle\langle+| & 0 \\ 0 & |-\rangle\langle-| \end{pmatrix}$$

We want to know either state.

According to the coupling structure, there is a strong tendency.



Effective Spin Reconstruction (II)

Definition :

- Use the lepton from top decay.
- Combine spin-basis.
  Ex. Helicity basis

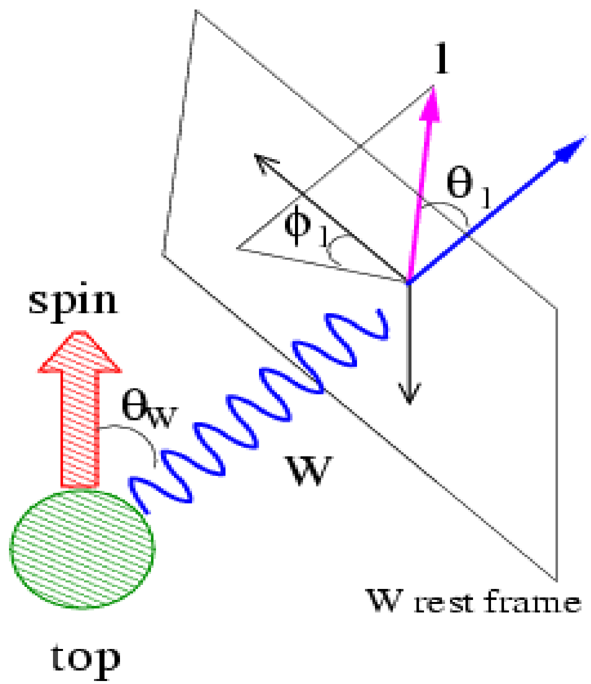
$$\vec{S} = \mathrm{sign}(\cos\Theta) \times \{\text{spin basis}\}$$

where $\cos\Theta \equiv \dfrac{\vec{n}\cdot\vec{p}_l}{|\vec{p}_l|}$

$$= \sin\theta_l \cos\phi_l \sin\theta_W + \frac{\cos\theta_l + \beta_W}{\sqrt{1-\beta_W^2}} \cos\theta_W$$

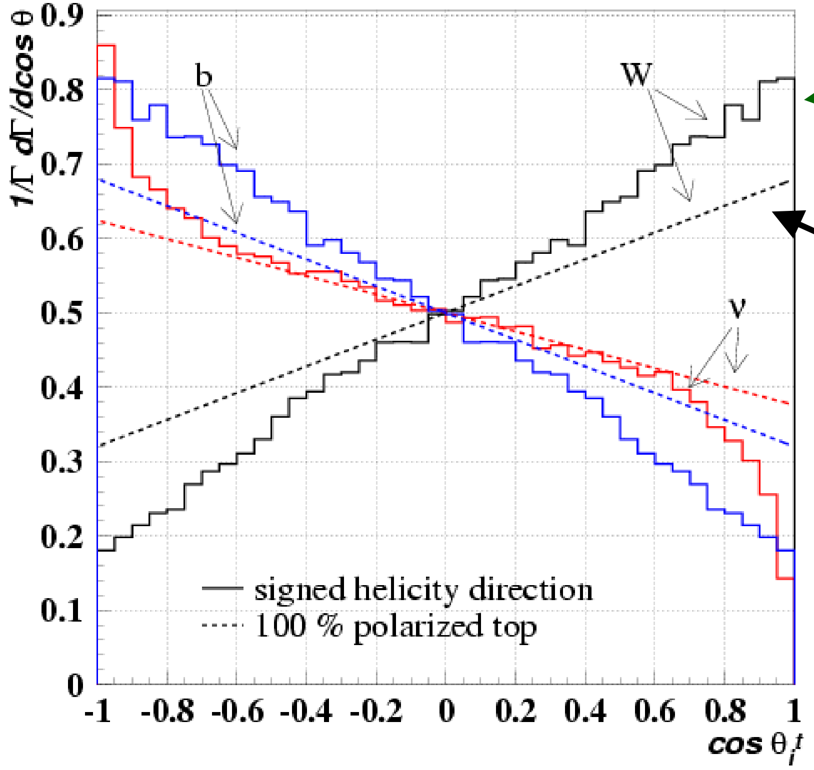
$$\beta_W = \frac{M_t^2 - M_W^2}{M_t^2 + M_W^2}$$

n is an arbitrary unit vector (spin-basis).



The sign(cosΘ) define which state.

Effective Spin Reconstruction (III)



Reconstructed top spin vector using effective spin reconstruction method.

True spin direction from 100% polarized top quark.

The difference is due to the boost effect of W boson from top.

Choice of the spin basis depends on the analysis. (use optimal one.)

Search for anomalous couplings in top decay at CDF II

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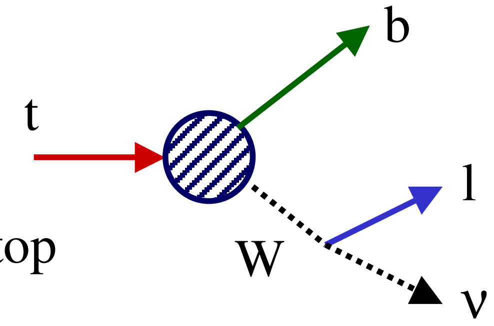
Okayama University
Y.Sumino
Tohoku University

Anomalous Coupling

The anomalous couplings in top decay are expressed as

$$\begin{cases} \Gamma^{\mu}_{Wtb} = -\frac{g_W}{\sqrt{2}} V_{tb}\, \bar{u}(p_b)\left[\gamma^{\mu} f_1^L P_L - \frac{i\sigma^{\mu\nu} p_{W\nu}}{M_W} f_2^R P_R\right] u(p_t) & \text{for top} \\ \bar{\Gamma}^{\mu}_{W\bar{t}\bar{b}} = -\frac{g_W}{\sqrt{2}} V^*_{tb}\, \bar{v}(p_{\bar{t}})\left[\gamma^{\mu} \bar{f}_1^L P_L - \frac{i\sigma^{\mu\nu} p_{W\nu}}{M_W} \bar{f}_2^L P_L\right] v(p_{\bar{b}}) & \text{for anti-top} \end{cases}$$



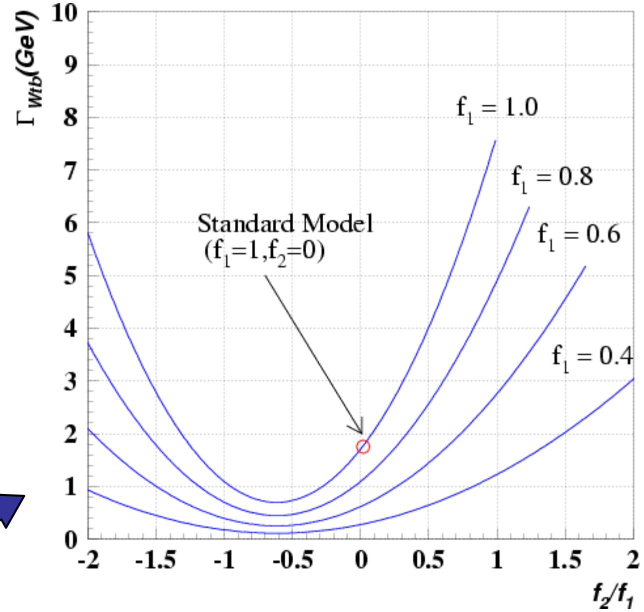
where $P_L = (1 - \gamma_5) / 2$ and $P_R = (1 + \gamma_5) / 2$.

Two anomalous parameters: f_1 and f_2 .

Decay distribution is sensitive to f_2/f_1 .

We measure f_2/f_1 .

Slope is quadratic function.

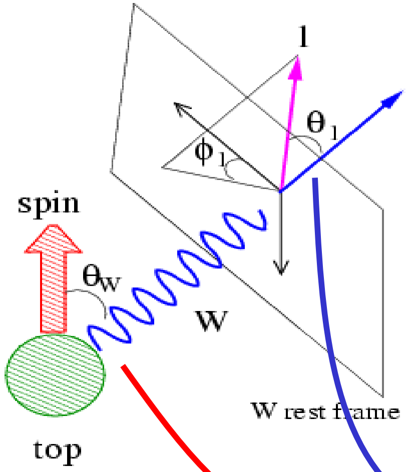


Kinematical Distribution (I)

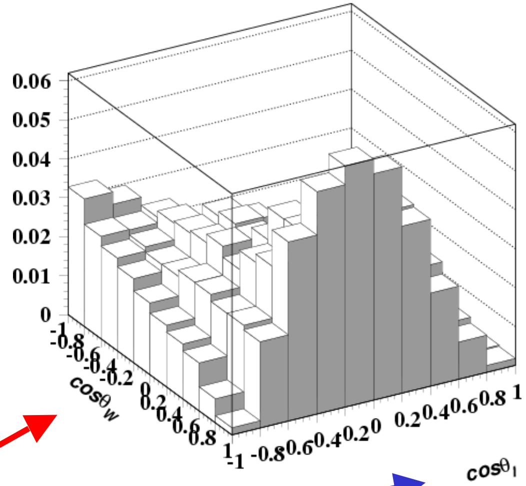
Differential decay distribution from polarized top-quark for f_{1L}=1(tree level),

$$\frac{d\Gamma(t_{\uparrow} \to b l \nu)}{d\cos\theta_W \, d\cos\theta_l}$$

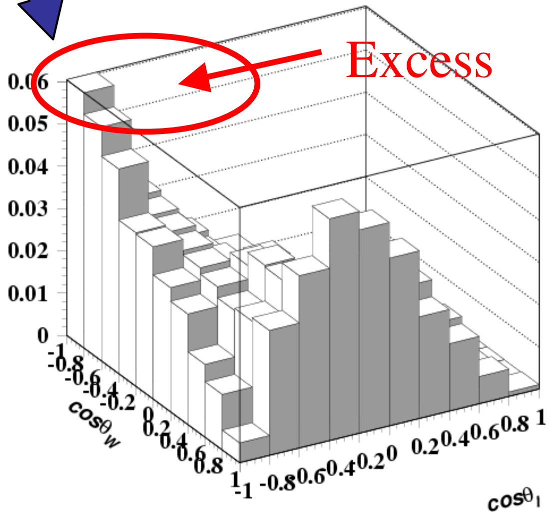
The W_T component is enhanced



SM (f_1=1.0, f_2=0.0)



(f_1=1.0, f_2=0.3)



Lepton helicity angle

Angle between top spin and W

Note : using true spin.

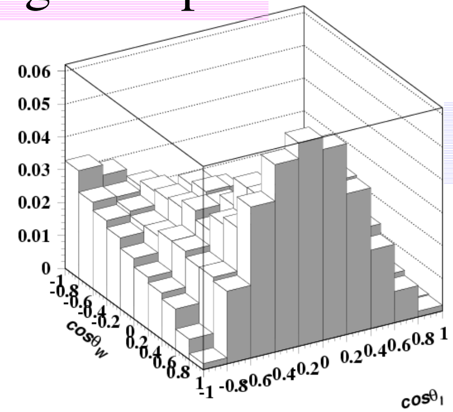
Kinematical Distribution (II)

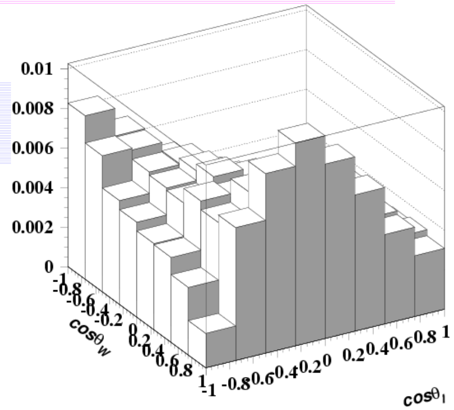
Using our spin reconstruction method…

Using true spin

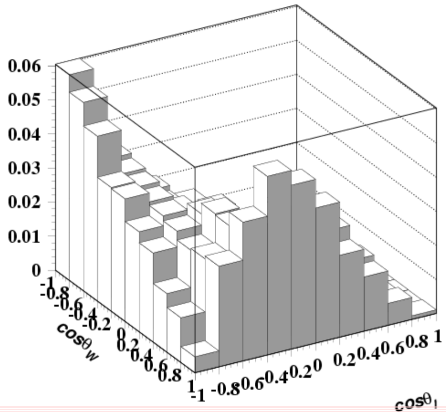
Using effective spin

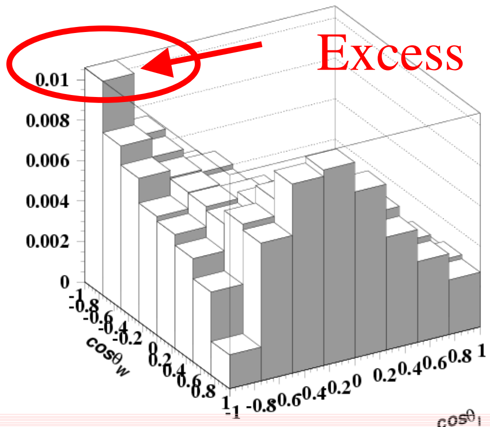
SM (f_1=1.0, f_2=0.0)





(f_1=1.0, f_2=0.3)





Impossible to reconstruct by the analysis level.

Possible to reconstruct by the analysis level.

Event reconstruction (L+jets channel)

Signal MC :

GR@PPA-PYTHIA with anomalous couplings (M_{top} = 178 GeV)

Data :

318pb^{-1} with top standard selection criteria with Secvtx tagger.

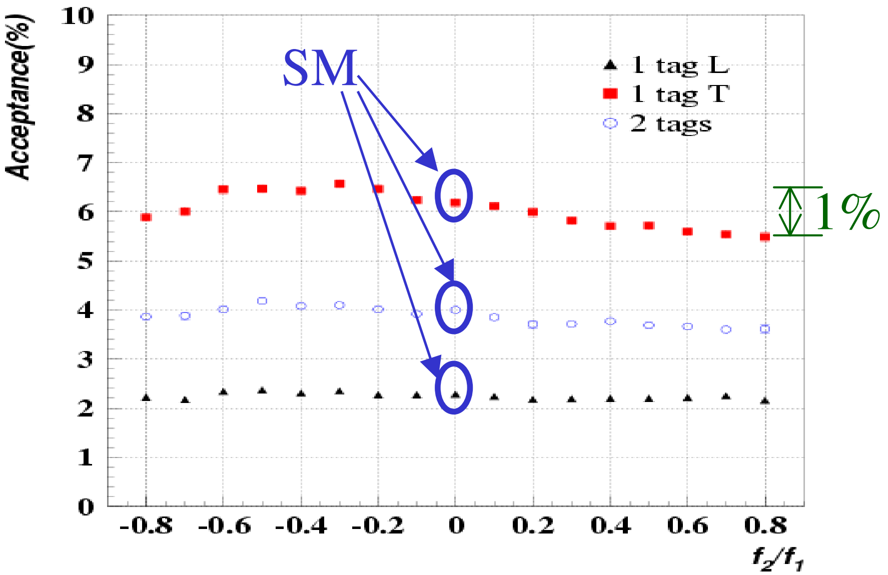
Kinematical reconstruction :

Chi square kinematical fitter (with mass constrained fit of top and W).

2tags / 1tag + 4 tight jets / 1tag + 3.5 jets events are used.

Acceptance fluctuates within 1% to the various anomalous couplings.

(Note that the denominator of Acc. includes the branching ratio to L+4p.)



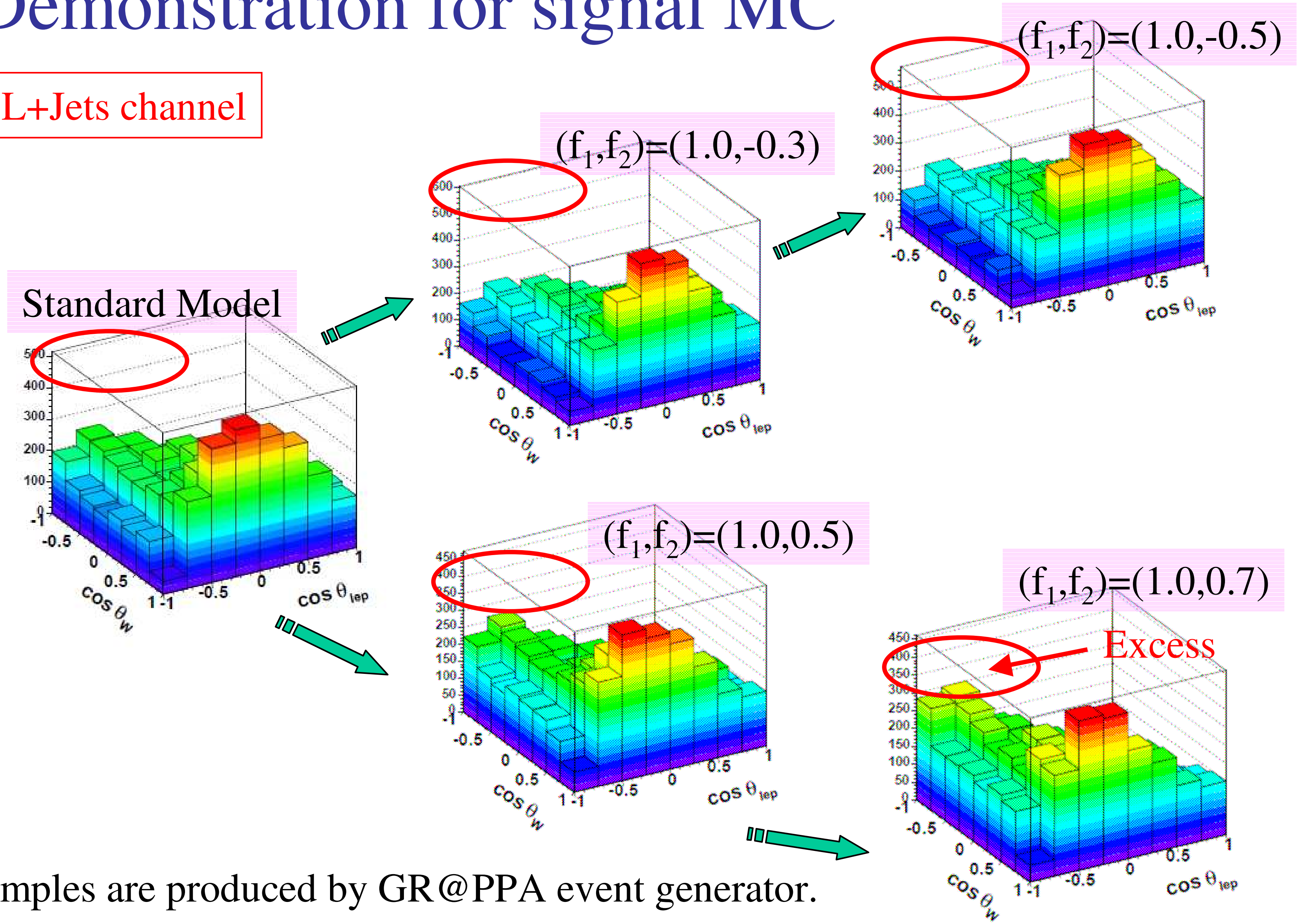
Signal and backgrounds

These samples are used.

Unoptimized Summary					
Jet Multiplicity	1 jet	2 jets	3 jets	4 jets	$\geq$ 5 jets
Pretags					
Data	30628	4791	769	179	36
$t\bar{t}$ (8.9 pb)	9.20 $\pm$ 0.82	49.55 $\pm$ 4.40	96.66 $\pm$ 8.58	86.37 $\pm$ 7.67	26.63 $\pm$ 2.38
$\geq$ 1 Tags					
EW	4.47 $\pm$ 0.69	8.47 $\pm$ 1.25	2.10 $\pm$ 0.34	0.39 $\pm$ 0.08	0.10 $\pm$ 0.03
Single Top	6.86 $\pm$ 1.71	11.55 $\pm$ 2.42	2.50 $\pm$ 0.53	0.41 $\pm$ 0.09	0.06 $\pm$ 0.01
Non-W	42.25 $\pm$ 10.05	19.34 $\pm$ 4.77	6.70 $\pm$ 1.92	3.07 $\pm$ 1.06	0.61 $\pm$ 0.39
W + LF Mistags	94.05 $\pm$ 19.28	39.12 $\pm$ 7.86	11.05 $\pm$ 2.24	2.27 $\pm$ 0.45	0.22 $\pm$ 0.05
$W + c$	99.23 $\pm$ 26.61	21.06 $\pm$ 6.03	3.22 $\pm$ 0.98	0.51 $\pm$ 0.23	0.02 $\pm$ 0.02
$W + c\bar{c}$	33.52 $\pm$ 10.17	20.13 $\pm$ 6.60	4.88 $\pm$ 1.70	0.81 $\pm$ 0.40	0.02 $\pm$ 0.02
$W + b\bar{b}$	98.74 $\pm$ 32.37	55.13 $\pm$ 17.85	10.94 $\pm$ 3.44	1.70 $\pm$ 0.79	0.12 $\pm$ 0.12
$t\bar{t}$ (8.9 pb)	3.08 $\pm$ 0.35	25.19 $\pm$ 2.66	55.28 $\pm$ 5.74	53.78 $\pm$ 5.50	16.80 $\pm$ 1.73
Bkg	379.12 $\pm$ 72.53	174.80 $\pm$ 32.04	41.39 $\pm$ 6.84	9.16 $\pm$ 1.83	1.15 $\pm$ 0.43
Bkg + $t\bar{t}$ (8.9 pb)	382.20 $\pm$ 72.53	199.99 $\pm$ 32.15	96.67 $\pm$ 8.93	62.94 $\pm$ 5.80	17.95 $\pm$ 1.78
Data	432	242	95	63	19
$\geq$ 2 Tags					
EW	-	0.42 $\pm$ 0.09	0.14 $\pm$ 0.04	0.02 $\pm$ 0.01	0.01 $\pm$ 0.01
Single Top	-	1.52 $\pm$ 0.29	0.53 $\pm$ 0.13	0.09 $\pm$ 0.03	0.02 $\pm$ 0.01
Non-W	-	0.29 $\pm$ 0.17	0.90 $\pm$ 0.50	0.78 $\pm$ 0.49	0.34 $\pm$ 2.64
W + LF Mistags	-	0.55 $\pm$ 0.12	0.30 $\pm$ 0.06	0.20 $\pm$ 0.04	0.08 $\pm$ 0.05
$W + HF$	-	8.39 $\pm$ 2.93	1.84 $\pm$ 0.62	0.34 $\pm$ 0.16	0.03 $\pm$ 0.02
$t\bar{t}$ (8.2 pb)	-	4.28 $\pm$ 0.70	11.68 $\pm$ 1.91	14.06 $\pm$ 2.27	4.63 $\pm$ 0.74
Bkg	-	11.17 $\pm$ 2.96	3.71 $\pm$ 0.82	1.42 $\pm$ 0.52	0.48 $\pm$ 2.64
Bkg + $t\bar{t}$ (8.2 pb)	-	15.46 $\pm$ 3.04	15.39 $\pm$ 2.08	15.48 $\pm$ 2.33	5.11 $\pm$ 2.74
Data	-	15	17	16	3

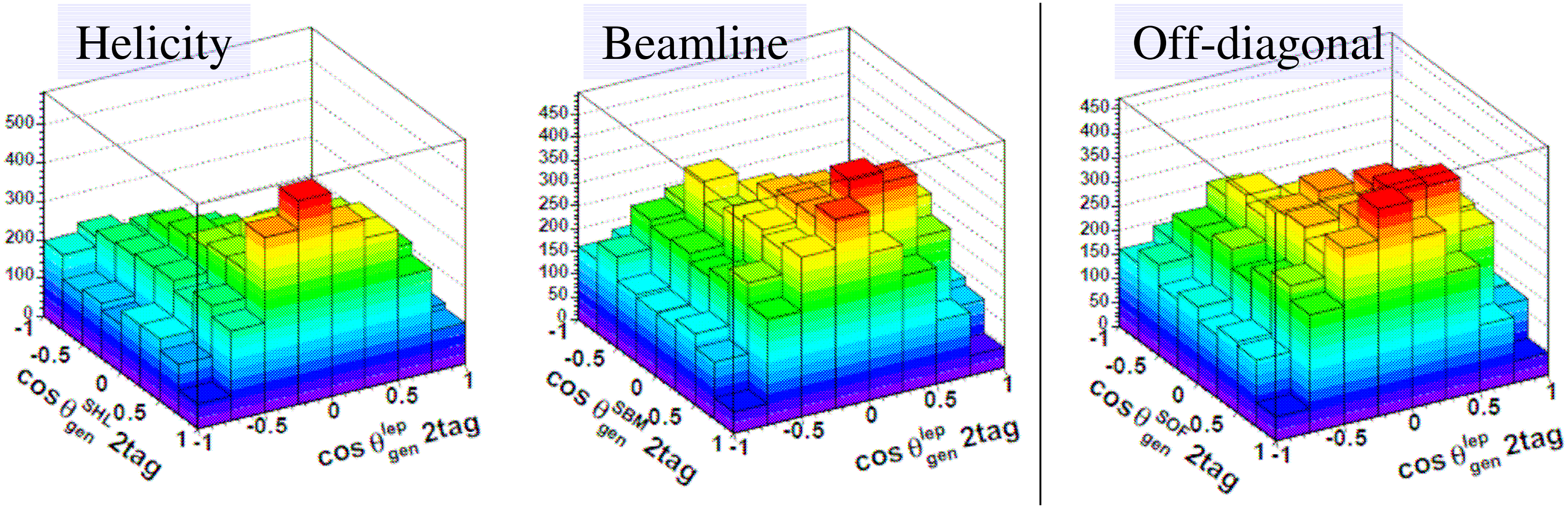
Demonstration for signal MC

L+Jets channel

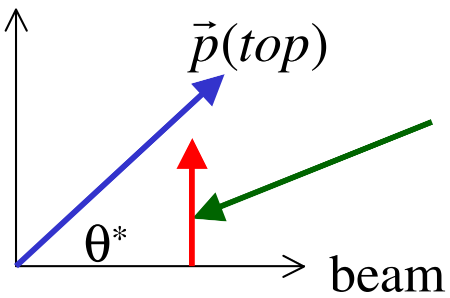


Samples are produced by GR@PPA event generator.

Other spin bases



So-call, threshold effect happens in the other bases, especially in 2 tag events. The reconstructed distribution does not reproduce the predicted shape by the kinematical cuts.

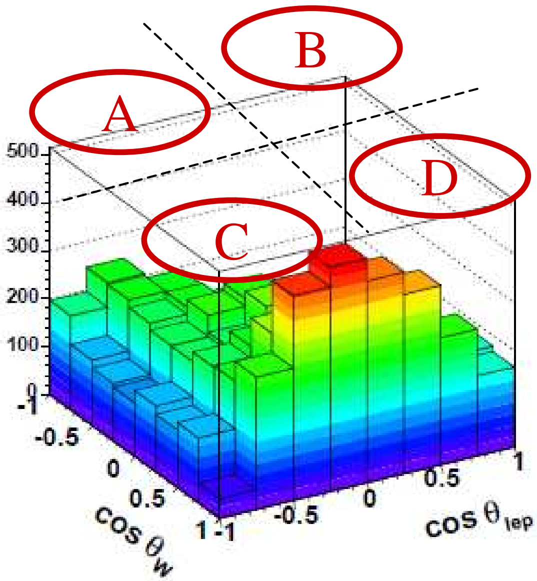


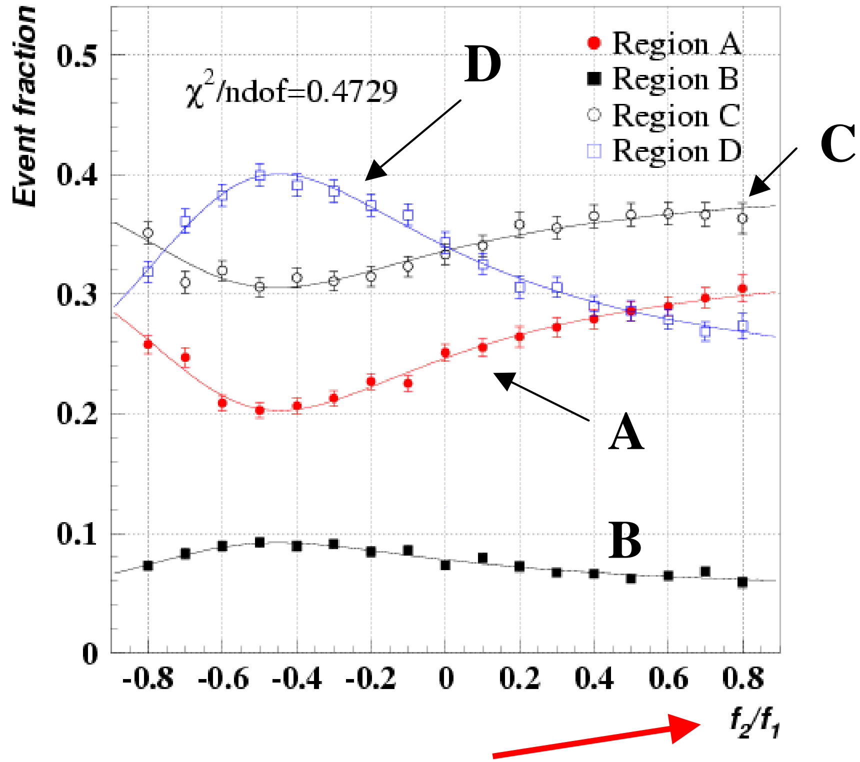
This angle is truncated by pt cut and η cut. On the other hand, our interest is edge region (cosθ ~ -1).

Sensitivity study

Count the number of events in Region A,B,C, and D.

1tagT





A and D are most sensitive regions.
B and C are less sensitive regions.

Anomalous coupling parameter.

Event fraction

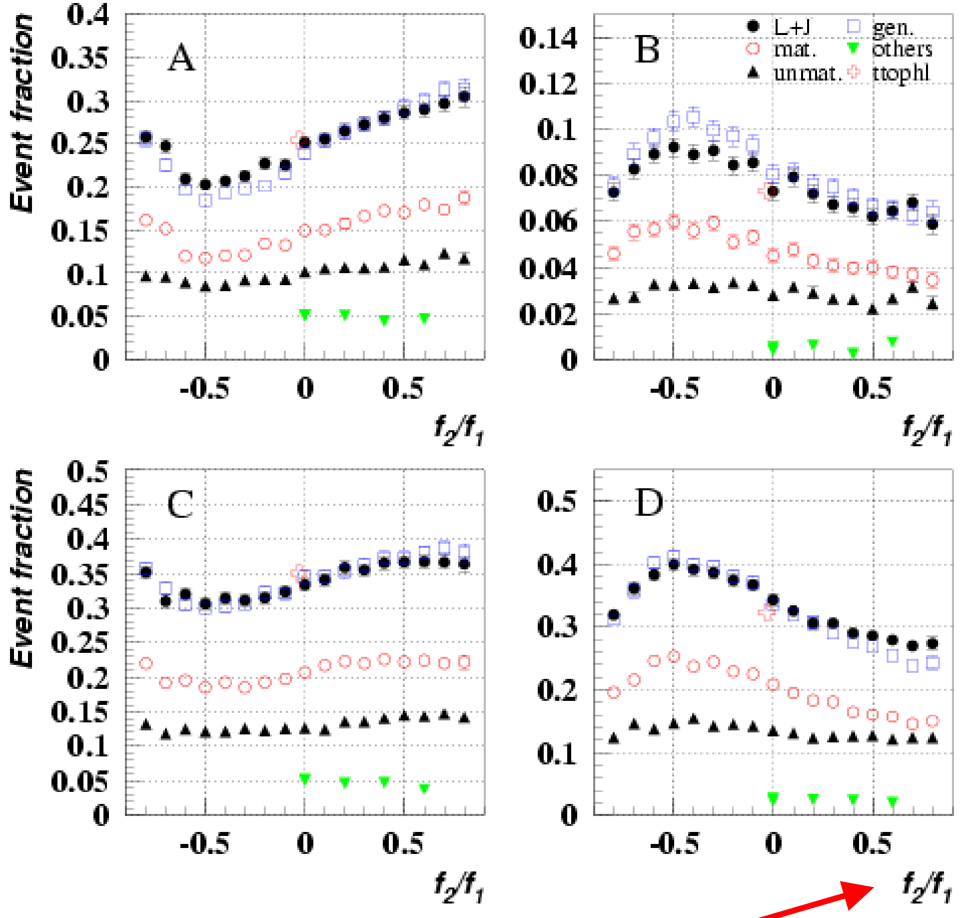
1tagT

Signal classification:

- ● **L + J : l + 4p evts.**
- ○ **mat. : matched in L+J**
- ▲ **unmat. : unmatched in L+J**
- □ **gen. : generator**
- ▼ **others : other decay mode (hadronic, tau)**
- ✠ **HERWIG (ttophl)**

Matching condition:
matched within $\Delta R<0.4$ between top momentum in L+J and gen.

Unmatched events reduce signal sensitivity.



Anomalous coupling parameter.

Parameterize the fraction

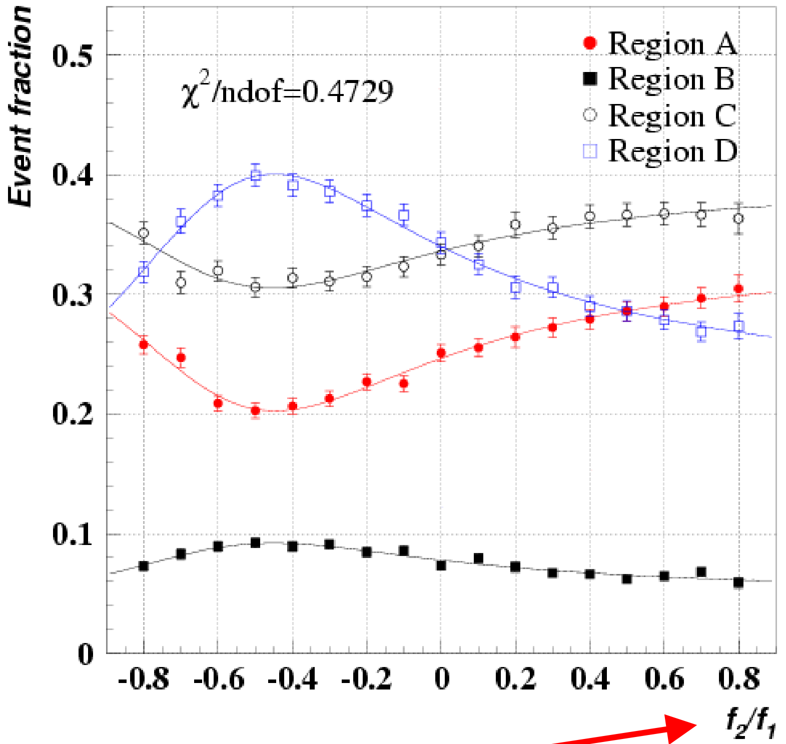
1tagT

The slop is given by theory.

$$\begin{cases} F_A(x) = \dfrac{1}{\Gamma_{tot}(x)} \displaystyle\int_{-1}^{0}\int_{-1}^{0} d\cos\theta_W \, d\cos\theta_l \Gamma(x) \\ F_B(x) = \quad \cdots \quad \displaystyle\int_{-1}^{0}\int_{0}^{1} \quad \cdots \\ F_C(x) = \quad \cdots \quad \displaystyle\int_{0}^{1}\int_{-1}^{0} \quad \cdots \\ F_D(x) = 1 - F_A(x) - F_B(x) - F_C(x) \end{cases}$$

(normalization condition)

where $x = \dfrac{f_2}{f_1}$



Anomalous coupling parameter.

Fitting function:

$$\Gamma_i(x) = a_1^{\ i} x^2 + a_2^{\ i} x + a_3^{\ i} \quad (i = A, B, C)$$

(total 9 fitting parameters)

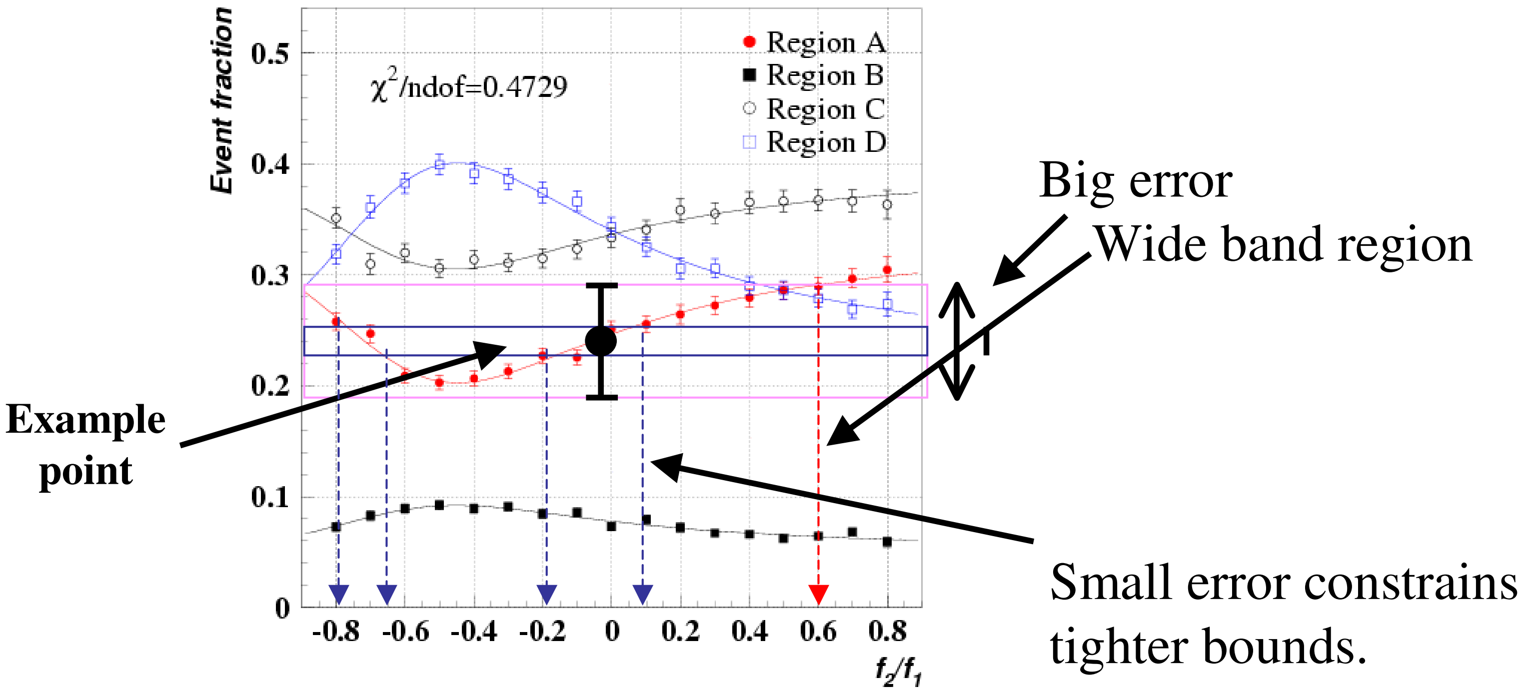
χ^2 fitting :

$$\chi^2 = \sum_j \left\{ \frac{(R_A^{\ j} - F_A(x))^2}{err(R_A^{\ j})^2} + \frac{(R_B^{\ j} - F_B(x))^2}{err(R_B^{\ j})^2} + \frac{(R_C^{\ j} - F_C(x))^2}{err(R_C^{\ j})^2} + \frac{(R_D^{\ j} - F_D(x))^2}{err(R_D^{\ j})^2} \right\}$$

where $R_A^{\ j} = \dfrac{N_A^{\ j}}{N_{tot}^{\ j}}$ etc.

Signal sensitivity (I)

- The size of error determines the bound on f2/f1.



- Up to 300 events plays a key role to improve bounds.
- The dip structure leaves two hold ambiguity.

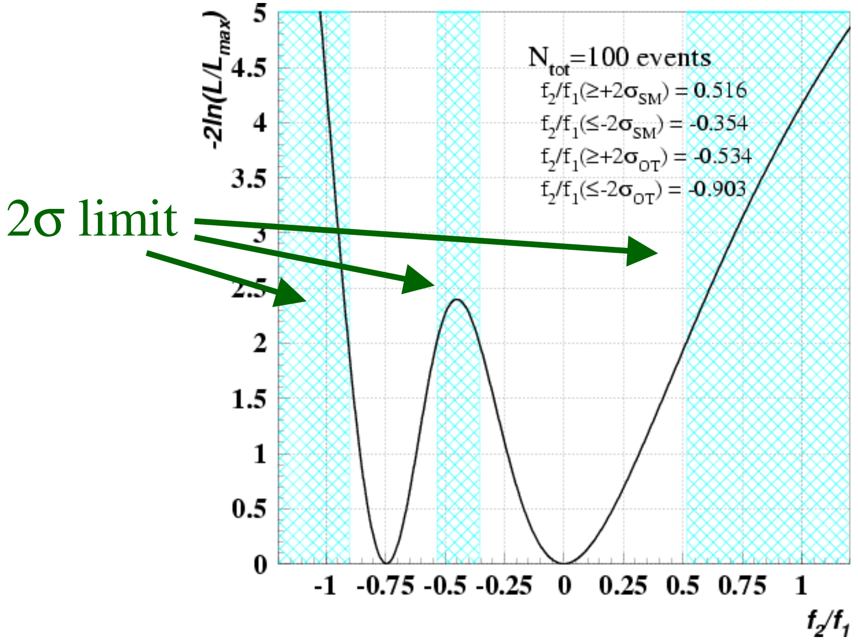
Signal sensitivity (II)

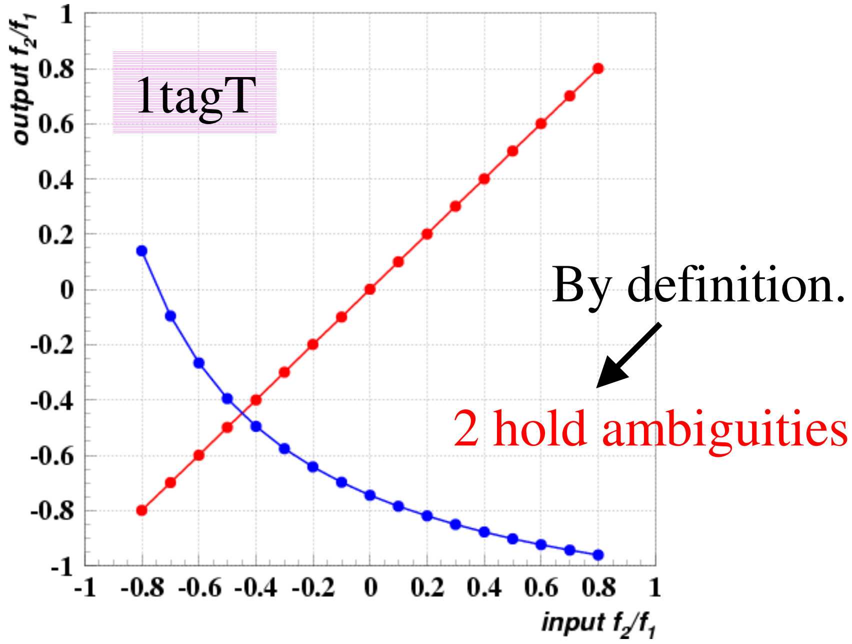
With fitting results, we can estimate the sensitivity.

Signal likelihood:

$$-2\ln L = \prod_{A,B,C,D} P_i(N_s + N_b \mid x = \frac{f_2}{f_1})$$

Signal only (no bkg.), stat. error (assumed to be 100 evts.) is only accounted.





Systematic uncertainty

Will be shown soon…

1tagT

Region	A	B	C	D
Top mass	0.0260	0.0119	0.0154	0.0275
Model	0.0012	0.0018	0.0058	0.0052
JES	0.0008	0.0020	0.0032	0.0031
ISR	0.0035	0.0020	0.0067	0.0082
FSR	0.0034	0.0021	0.0028	0.0041
PDF	0.0045	0.0014	0.0071	0.0053
PDF weighting	0.0020	0.0007	0.0011	0.0018

~ 10%

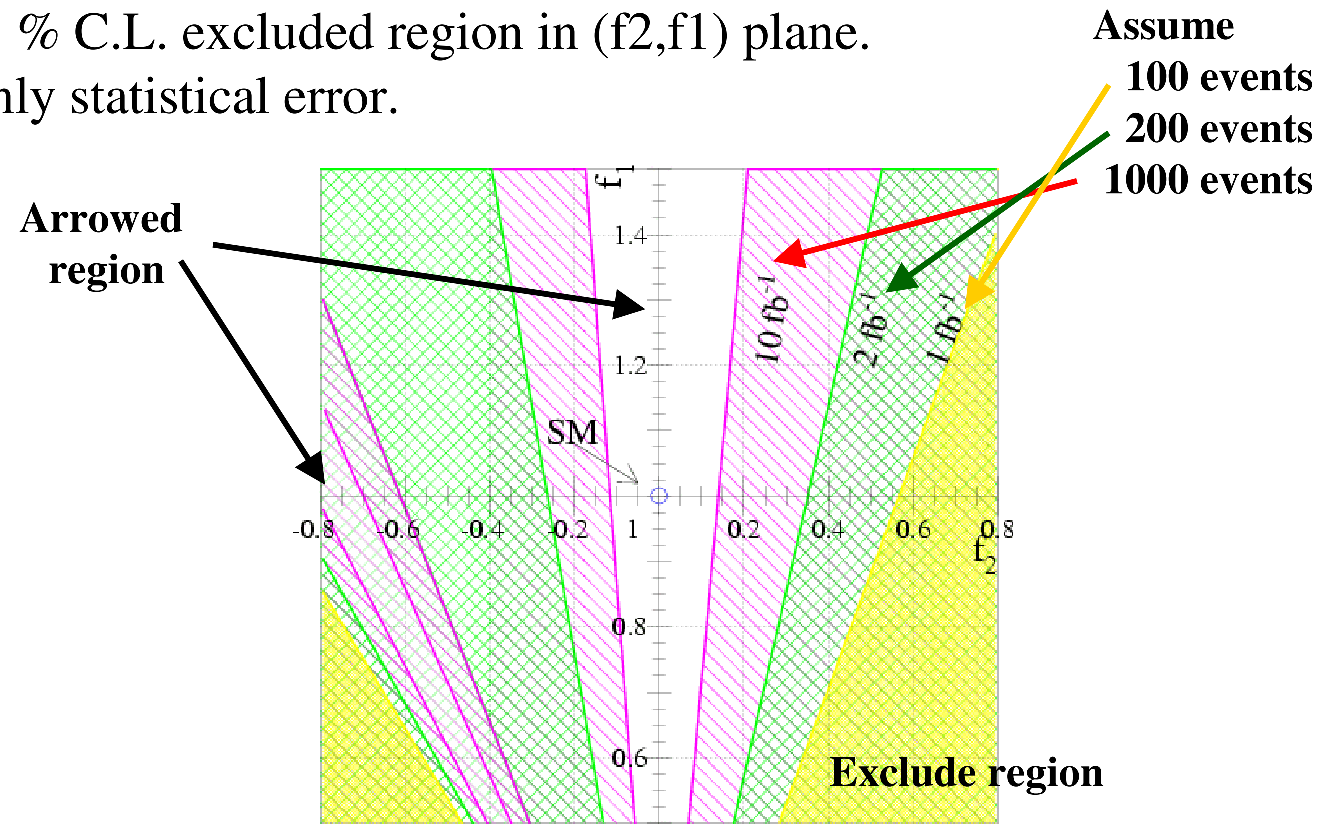
Result

? ? ?

Coming soon!!!

Sensitivity estimate

- 95 % C.L. excluded region in (f2,f1) plane.
- Only statistical error.

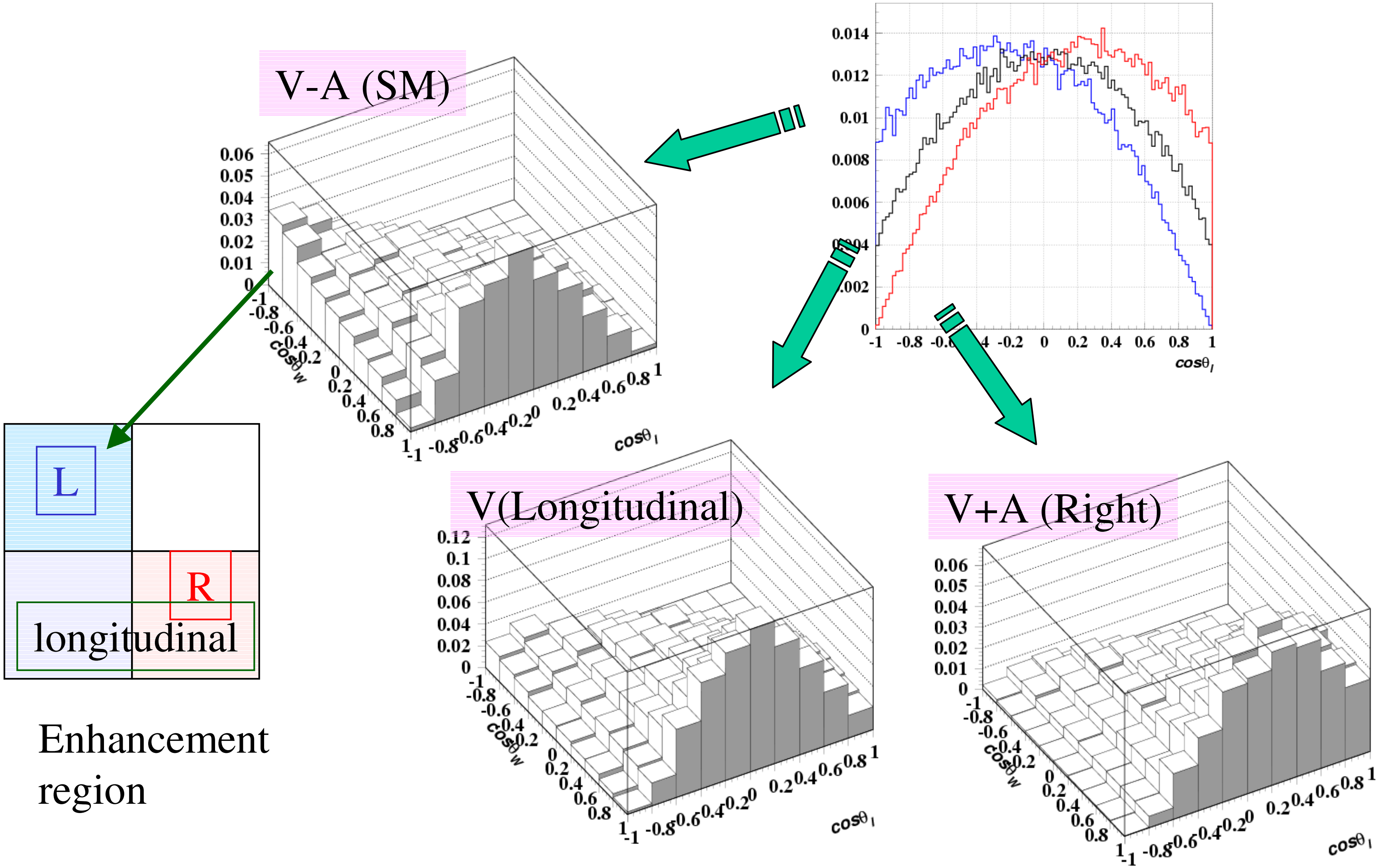


Rough estimate:

- With 100 top events (318pb^{-1}), will reach $-0.93 < f_2/f_1 < 0.57$.
- With 1000 top events (3 fb^{-1}), will reach $-0.12 < f_2/f_1 < 0.14$, $-0.81 < f_2/f_1 < -0.70$.

Other features

For example, apply it in the W helicity measurement.



Summary

- A new method for top spin reconstruction (using only top side).

- Expected bounds

  $-0.93 < f_2/f_1 < 0.57$ for 100 events,

  $-0.12 < f_2/f_1 < 0.14$, $-0.81 < f_2/f_1 < -0.70$ for 1000 events.

- Very important to analyze the $1fb^{-1}$ data. The bound drastically improves up to 300 events.

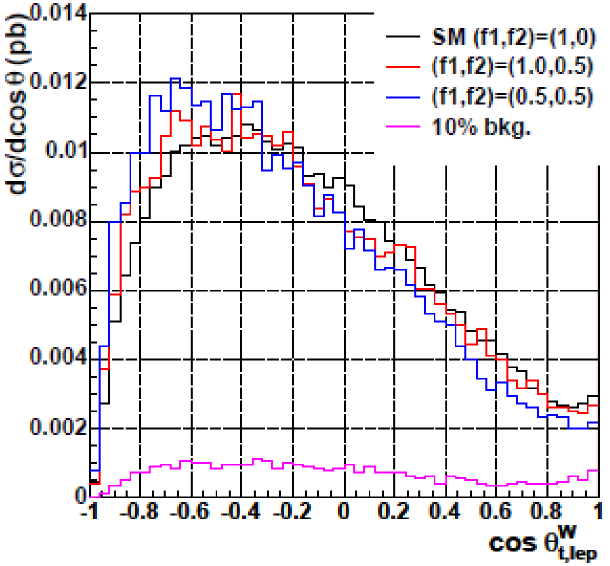
Result will come soon.

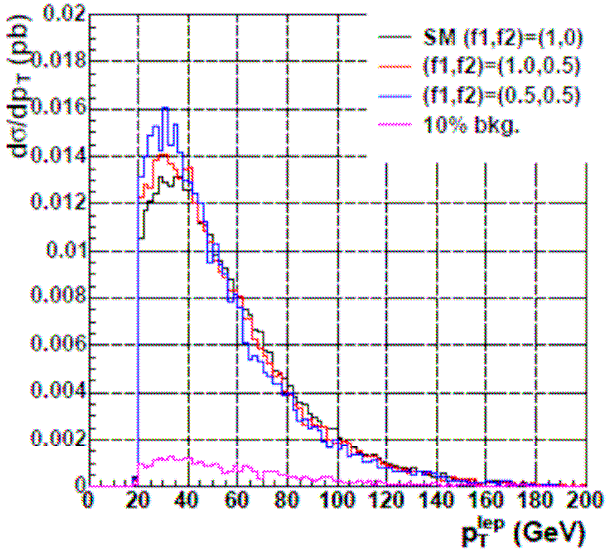
At LHC, the higher order effects in the top decay vertex may be also revealed using this analysis method…

Can effective spin reconstruction work for the discrimination to a new physics??

Kinematical shape

The physics of 'anomalous couplings' is not same as that of 'W helicity measurement'.



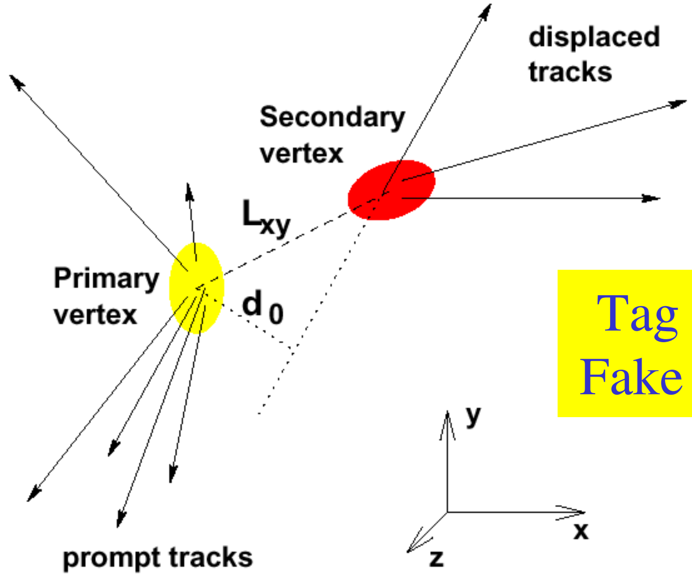


Those distribution can also constrain the anomalous couplings. But indirect.

Tagging high-p_T b-jets:

Silicon Vertex Tag

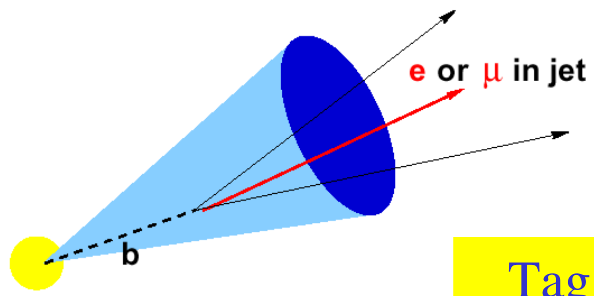
- Signature of a b decay is a displaced vertex:
  - Long lifetime of b hadrons ($c\tau \sim 450$ μm)+ boost
  - B hadrons travel L_{xy}~3mm before decay with large charged track multiplicity



Tag 55%
Fake 0.5%

Soft Lepton Tag

- Exploits the b quarks semi-leptonic decays
  - ⇒ These leptons have a softer p_T spectrum than W/Z leptons
  - ⇒ They are less isolated



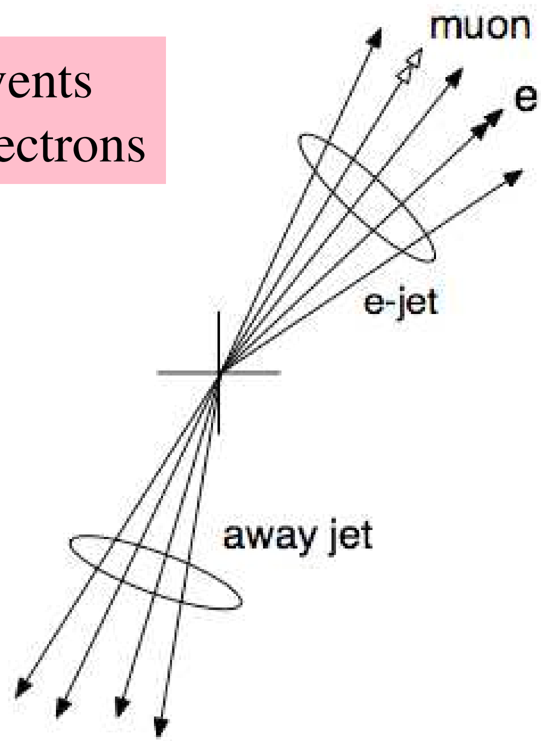
- $b \to \ell \nu c$ (BR ~ 20%)
- $b \to c \to \ell \nu s$ (BR ~ 20%)

Tag 15%
Fake 3.6%

Calibrating the b-tagging Efficiency

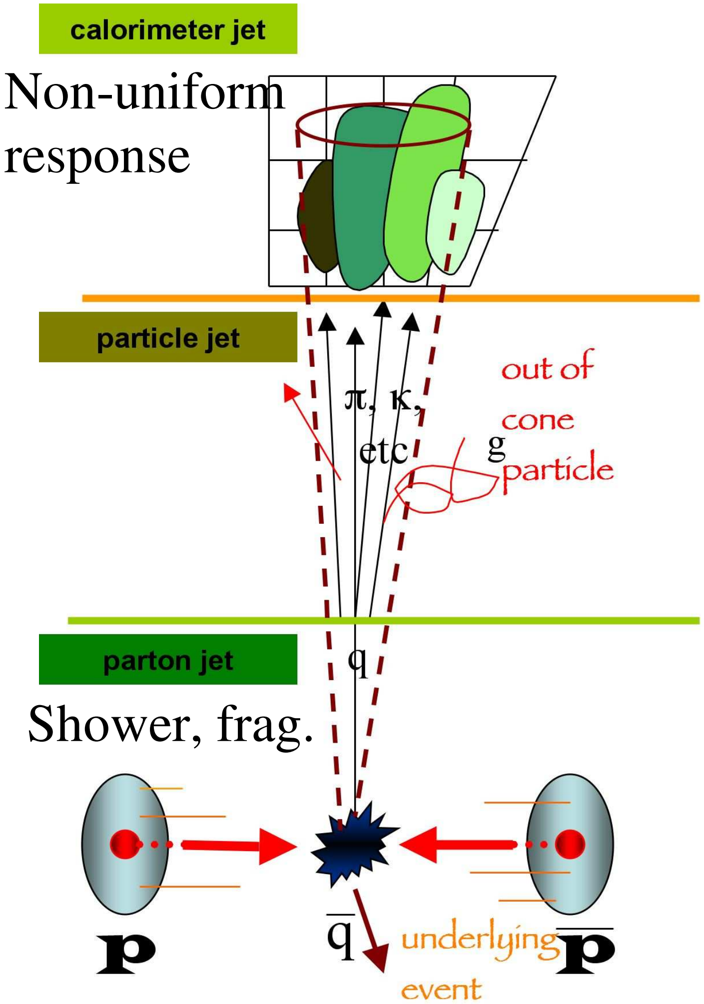
Measure ratio of single- and double-tagged events in b-enriched sample with soft (p_T>8 GeV) electrons

ϵ_{data}	$24.0 \pm 1.6\%$
ϵ_{MC}	$29.2 \pm 1.1\%$
ratio	$82 \pm 6\%$



Jet Energy Correction

Determine true "parton" E from measured jet E in a cone 0.4

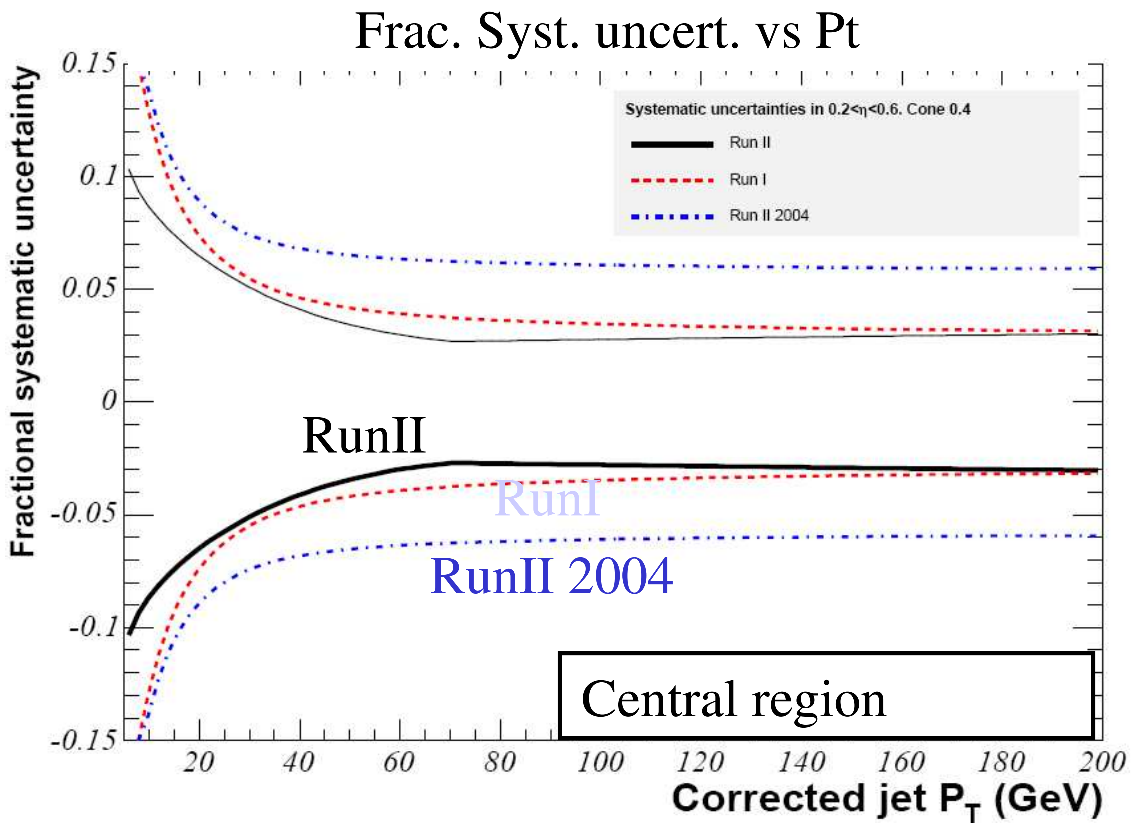


Correction to central region using dijet balance: to make response uniform in η

Correction to particle jets using dijet MC tuned for single particle E/P, material, and fragmentations: due to non-linear and non-compensating cal.

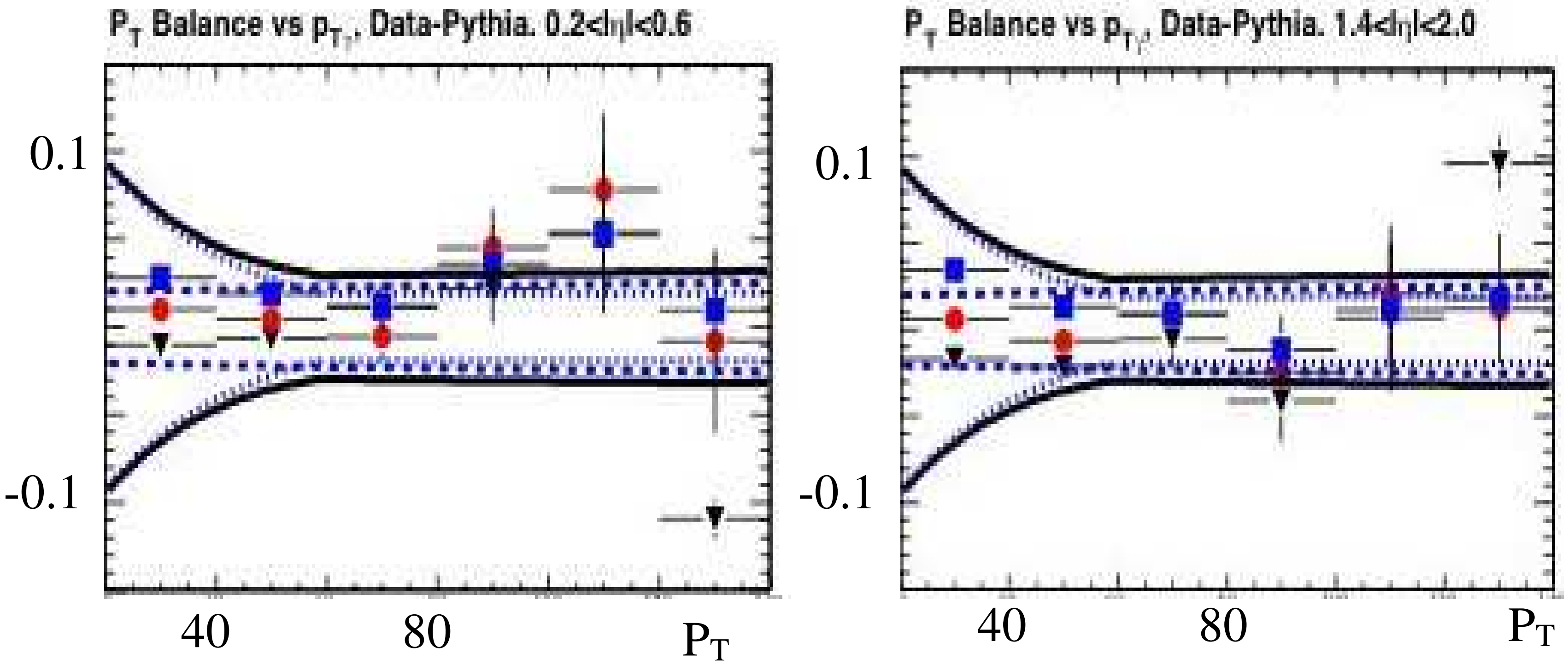
Out-of-Cone :correction to parton "top-specific correction" to light quark jets and b-jets separately

Jet Energy Systematic



A lot of work has been done to reduce the syst. from jet-energy scale (a factor of two improvement compared to last year). The new Run II systematic uncertainties are at the same level or better than Run I.

Crosscheck of Jet Energy Correction



Photon+jets, di-jet, Z+jets are used to cross-check the jet energy corrections. Observed differences between data, Pythia, and Herwig are contained by the jet systematic uncertainties in different η regions.

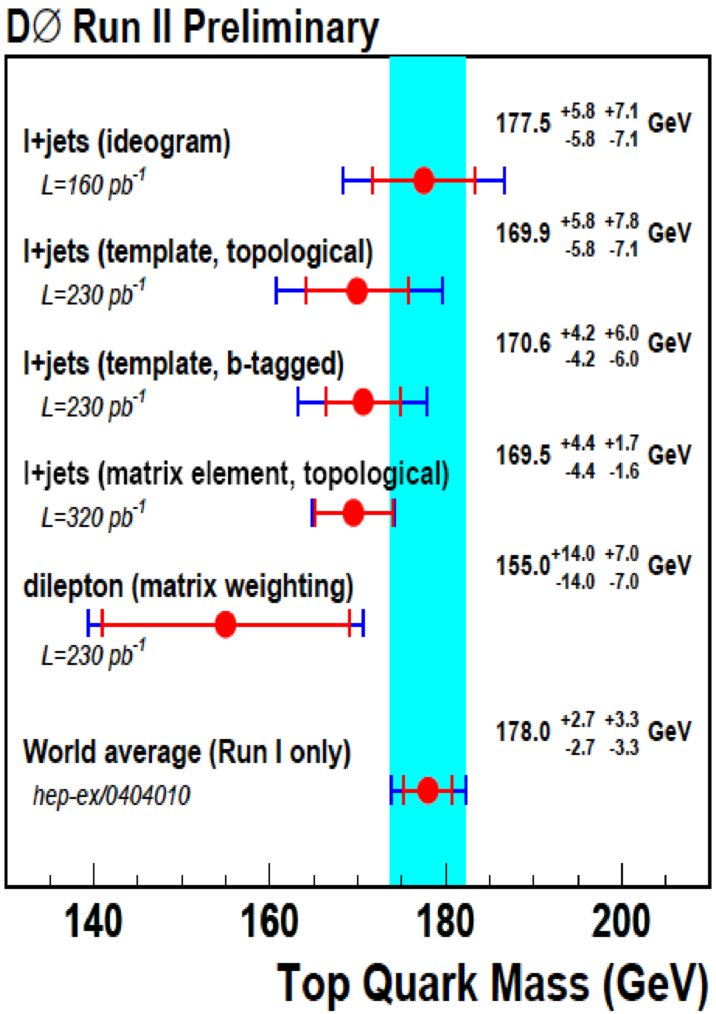
Kinematic Fitter

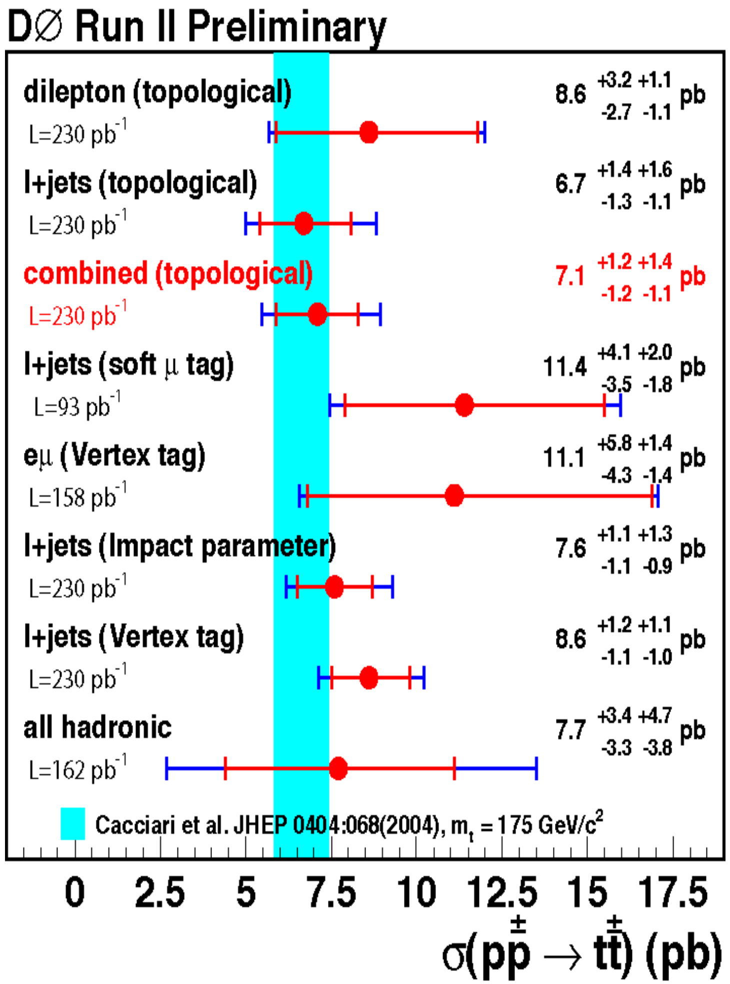
1. Try all jet-parton assignments with kinematic constraints, but assign b-tagged jets to b-partons
2. Select the rec. mass Mt from the choice of lowest χ^2
3. If necessary, badly reconstructed Mt ($\chi^2 > 9$) is removed

$$\chi^2 = \Sigma_{i=\ell,4jets} \frac{(\hat{p}_T^i - p_T^i)^2}{\sigma_i^2} + \Sigma_{j=x,y} \frac{(\hat{p}_j^{UE} - p_j^{UE})^2}{\sigma_j^2} + \frac{(m_{jj} - m_W)^2}{\Gamma_W^2} + \frac{(m_{\ell\nu} - m_W)^2}{\Gamma_W^2} + \frac{(m_{bjj} - m_t)^2}{\Gamma_t^2} + \frac{(m_{b\ell\nu} - m_t)^2}{\Gamma_t^2}$$

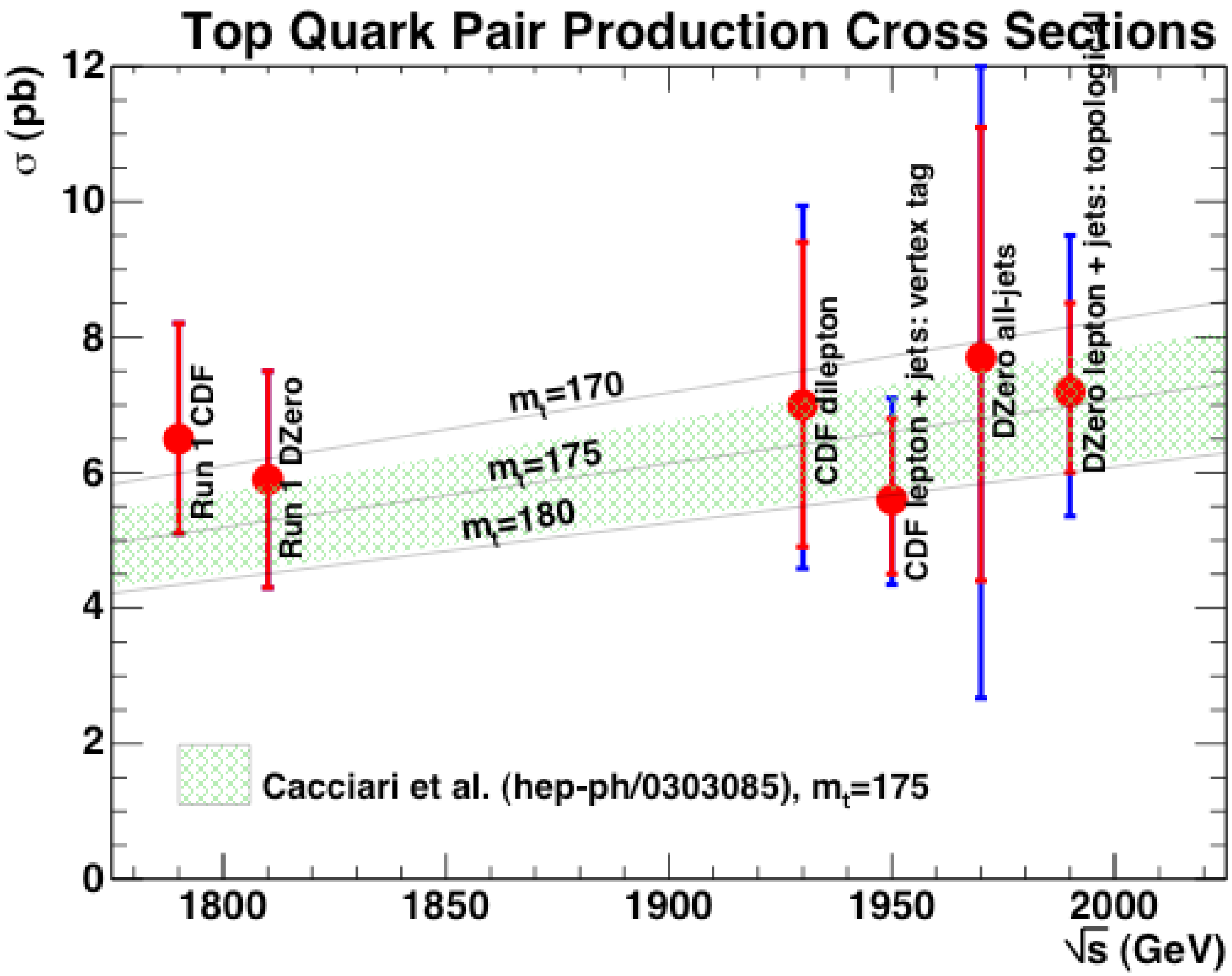
All jets are allowed to be float according to their resolutions to satisfy that M(W+)=M(W-)=80.4 GeV, M(t)=M($\bar{t}$)

Dzero results

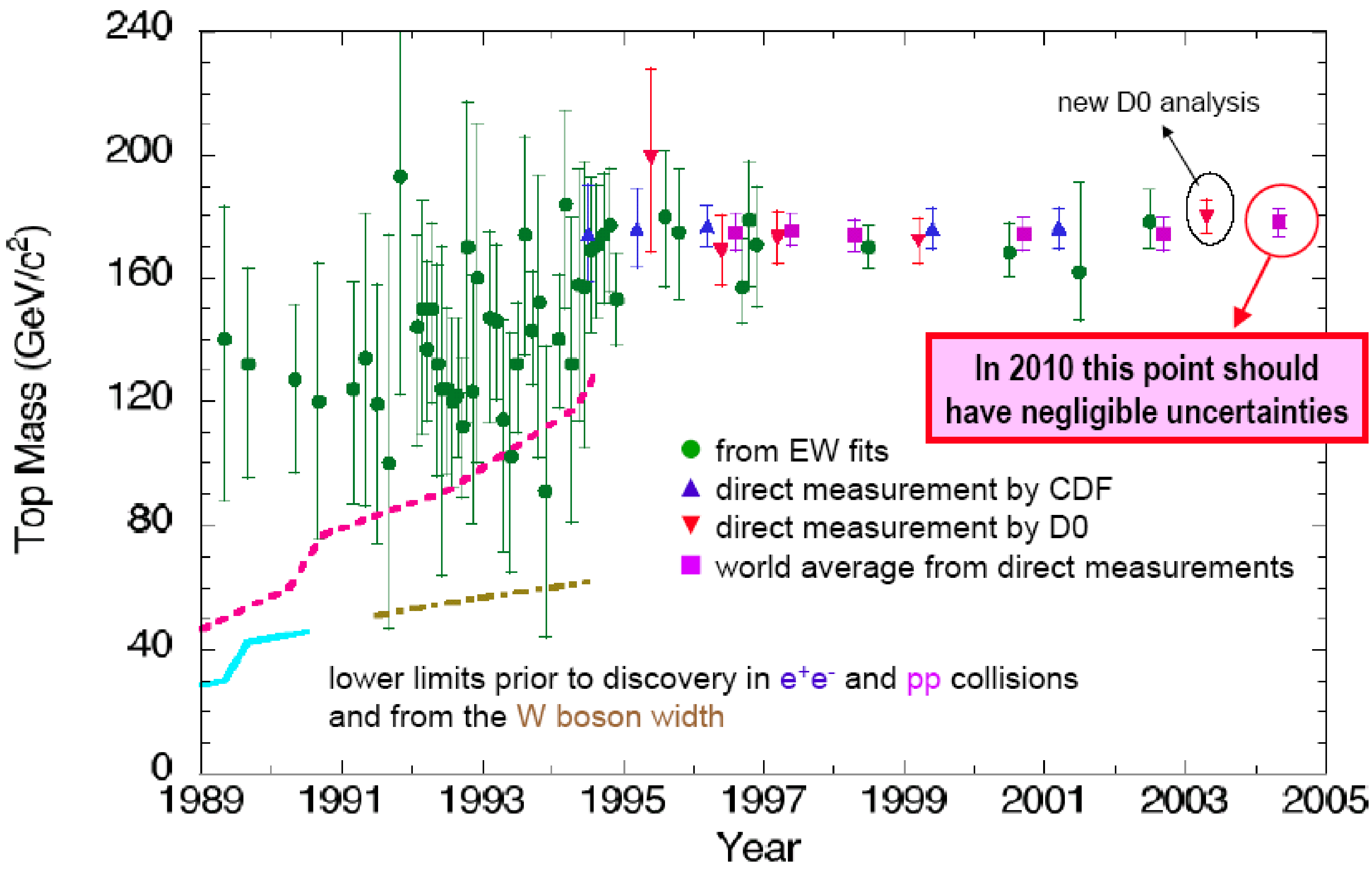




Comparison: Theory vs. Experiment

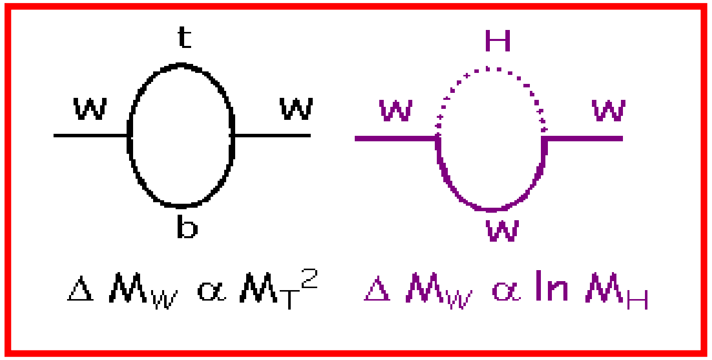


History: Top Mass Publications

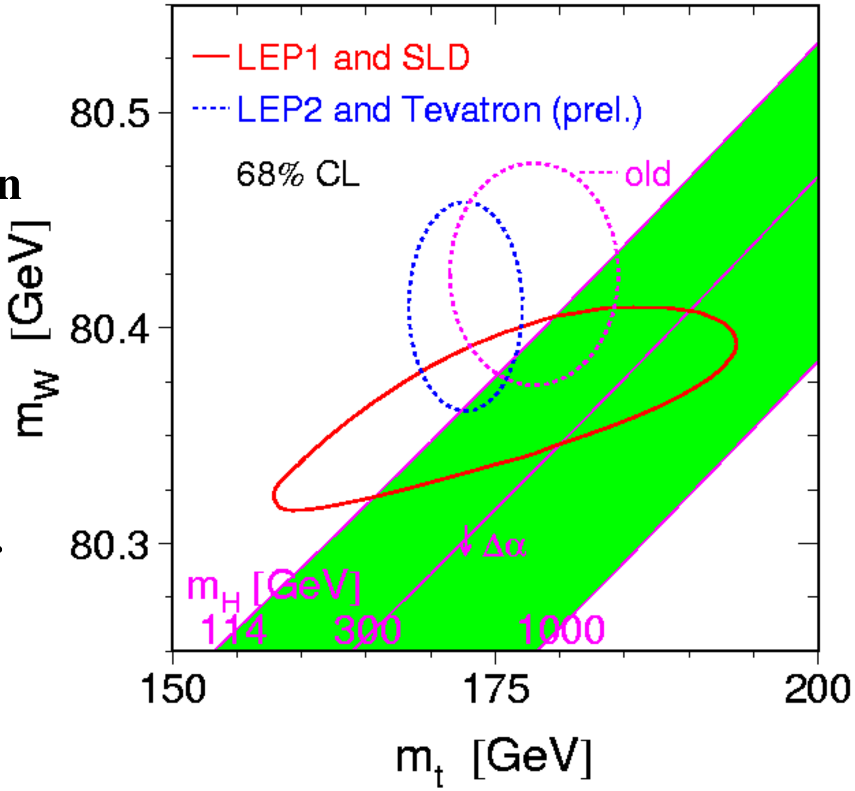


Indirect Higgs mass search with M_{top} and M_W

$$m_W^2 = \frac{\pi\ \alpha_{EM}}{\sqrt{2}\, G_F (1 - m_W^2 / m_Z^2)(1 - \Delta r)}$$



- **Higgs mass can be constrained from precise W mass and top quark mass measurements using the formula above. (radiative correction)**
- **Current CDF Run best single measurement $173.5^{+4.1}_{-4.0}$ GeV/c² and all combined value (Run I+Run II, CDF+D0, pick up best meas. in each channels) 172.7 ± 2.9 GeV/c²**
- **Current best M_W is inferred by LEP2 (80.392 0.039 GeV/c²), and world average is 80.410 ± 0.032 GeV/c².**
- **Best Higgs mass 91^{+45}_{-32} GeV/c² and upper limit 186 GeV/c² @ 95% C.L.**



Old : result in 2004