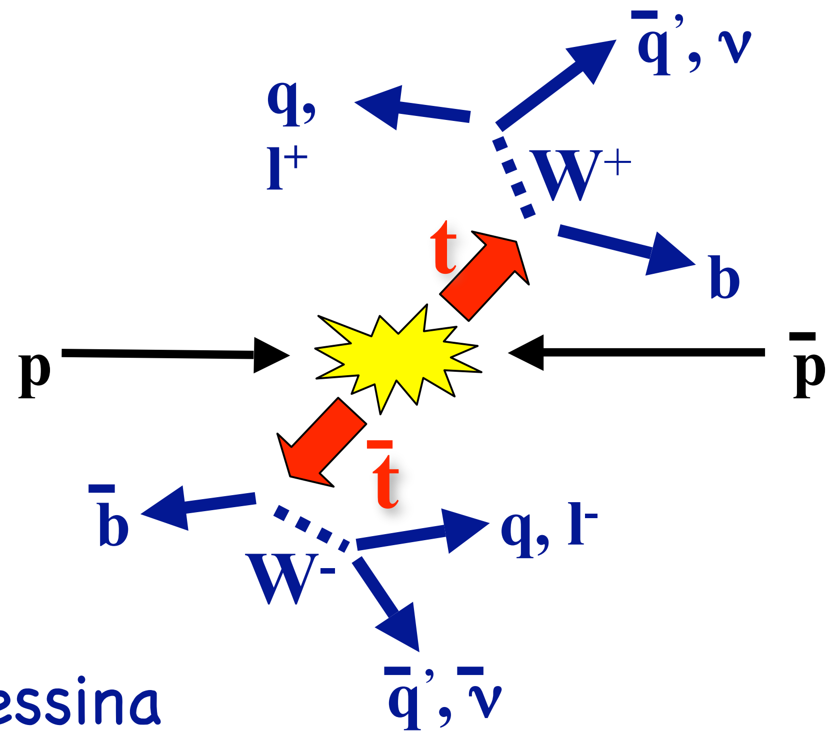
SM physics and beyond in top and W+jet events: latest results from CDF



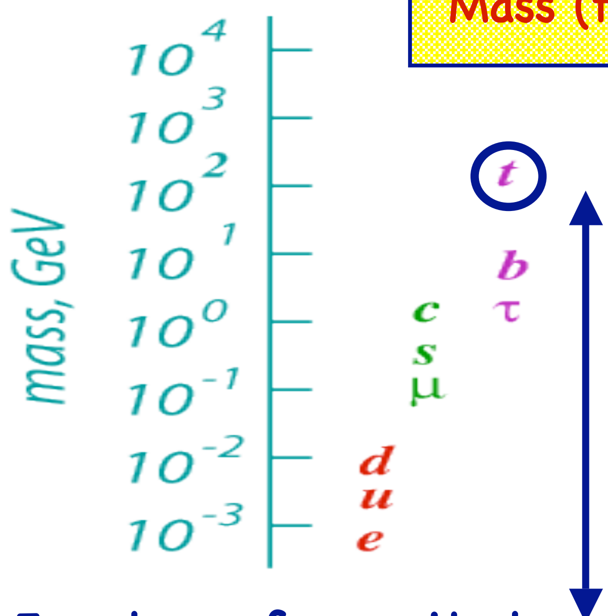
Andrea Messina

INFN Roma

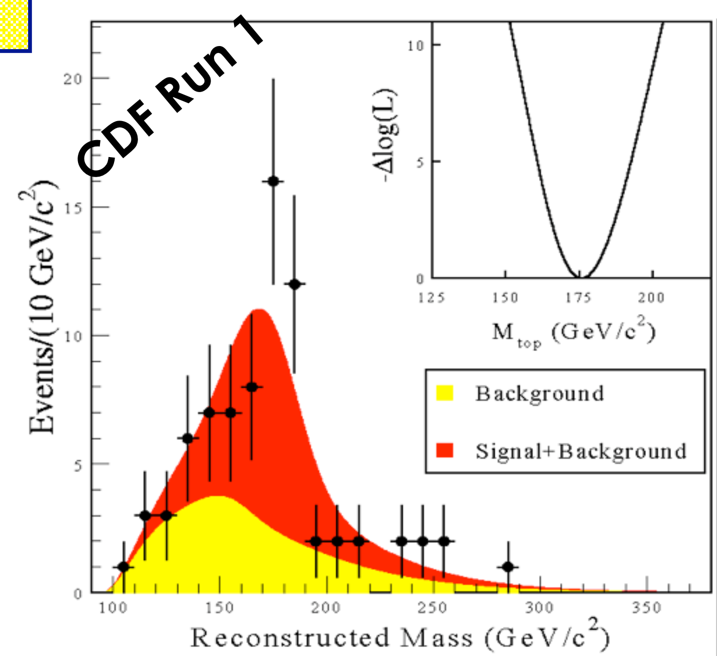
The top quark the discovery: 1995

- youngest member of the quark family
- discovered in 1995 at Tevatron
  - ✓ not a surprising discovery:
    - b-quark requires an isospin partner
- the search for top lasted 20 year due to its unexpectedly heavy mass

Run I CDF & D0 combined:
Mass (top) = 178 ± 4.3 GeV/c2



40x bottom quark mass
Comparable to gold nucleus



5 orders of magnitude

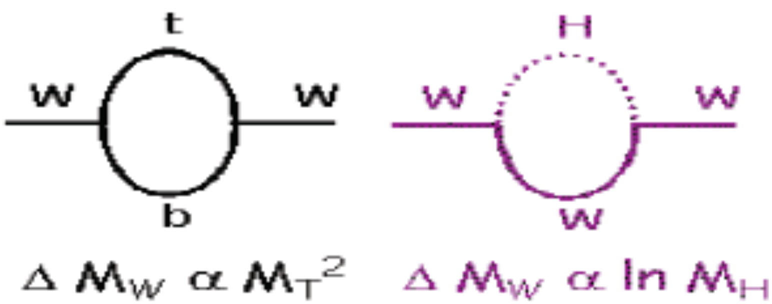
Why top quark is so interesting

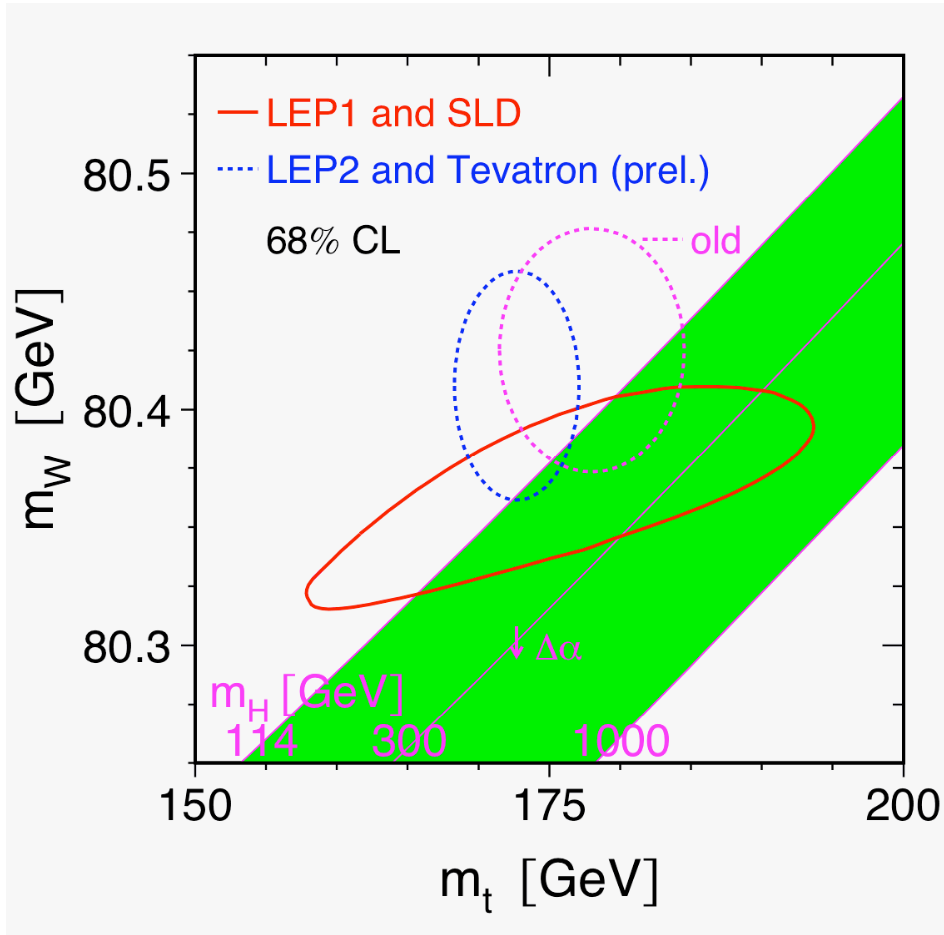
Top mass is a fundamental parameter of the SM:

✓ SM radiative correction dominated by top mass

✓ Special role in dynamic of EWSB $y_t=\sqrt{2}m_t/\langle V \rangle$

✓ together with W mass places a constraint on Higgs mass



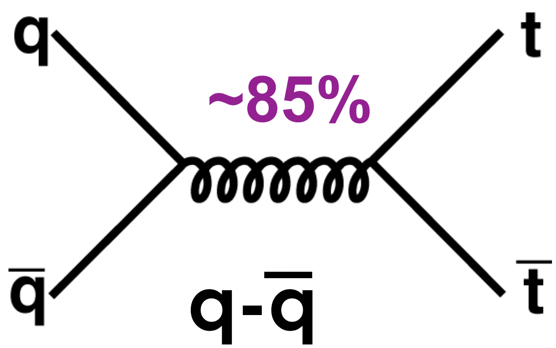


Tevatron: so far the only place to study the top

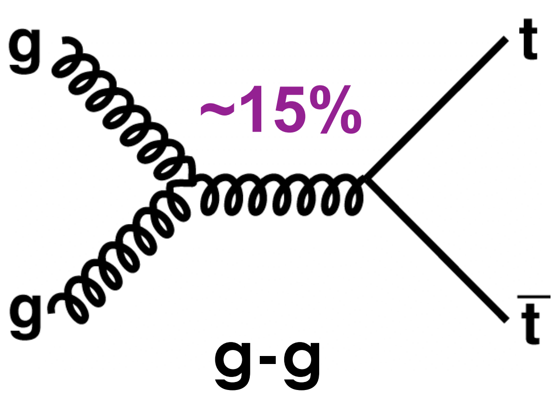
Signal of today, background of tomorrow!

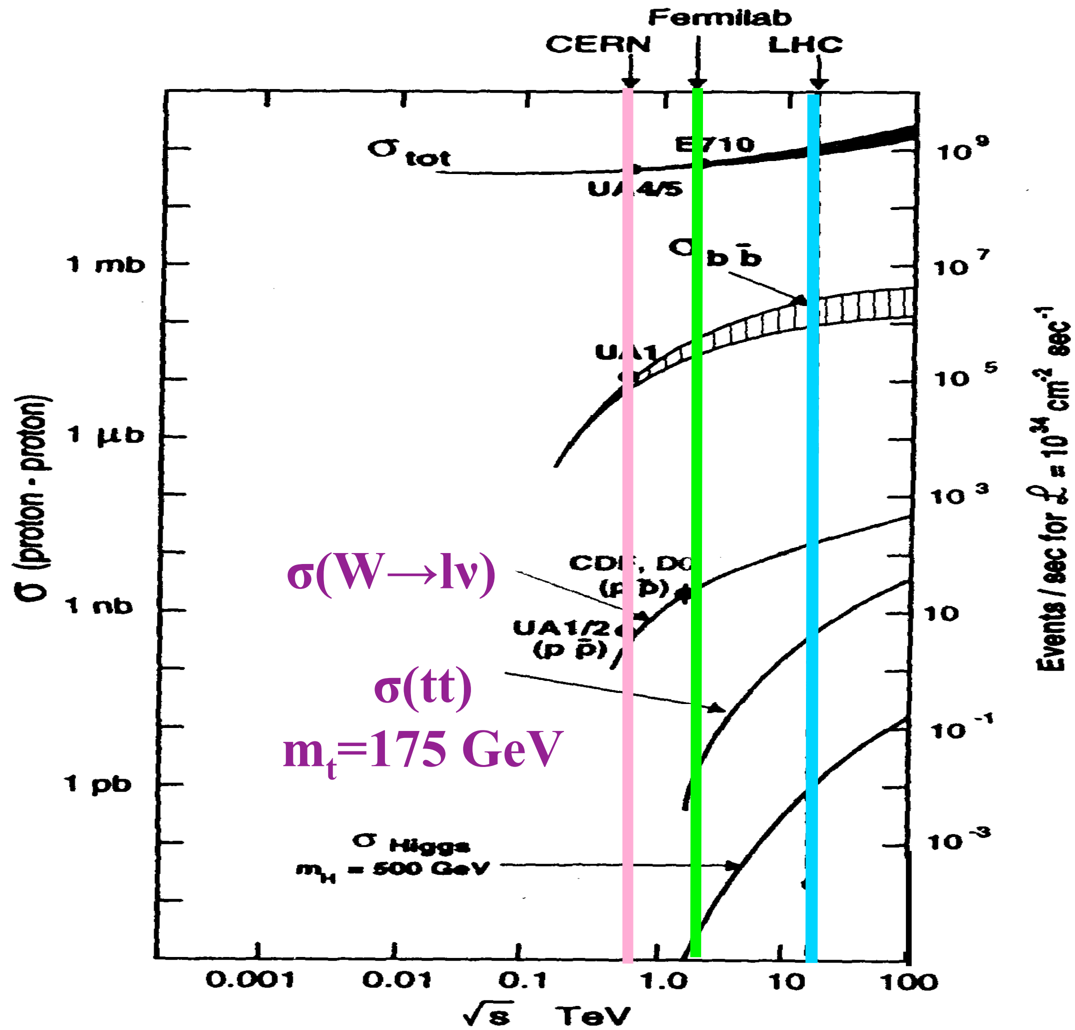
How top quark is produced

One top pair each 10^{10} inelastic collisions at $\sqrt{s}$ = 1.96 TeV



Standard Model
Pair Production
Through Strong Interaction





$$\sigma(\bar{p}p \rightarrow t\bar{t} \ @ M_{top} = 175 GeV) \approx 6.7 \text{ pb}$$

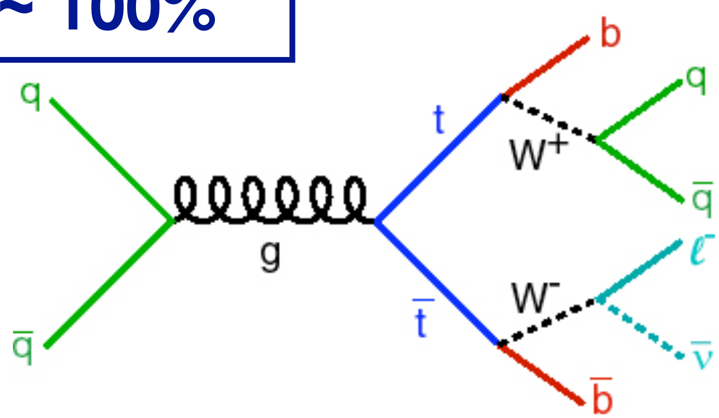
How does top quark dacay?

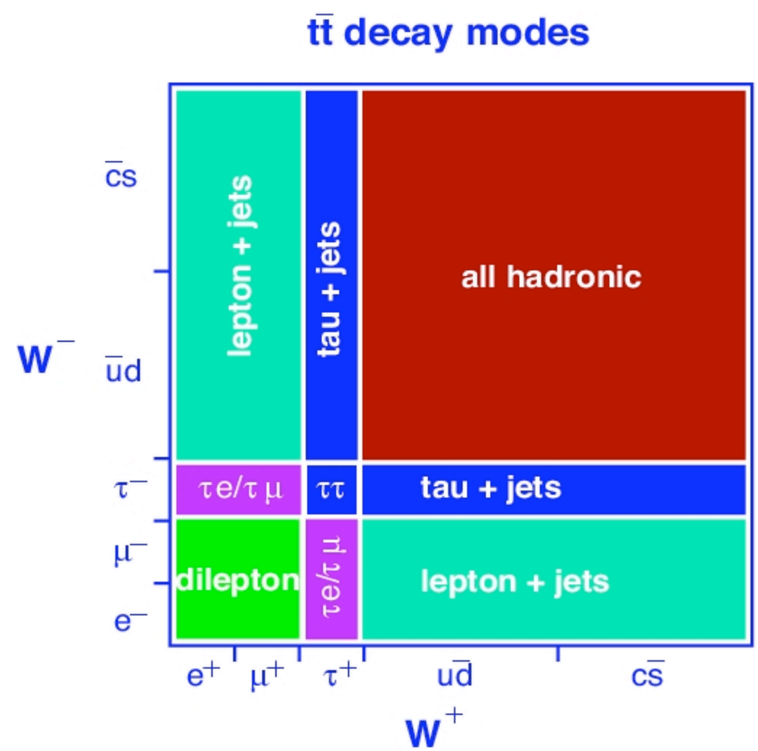
Top quark lifetime is short: decays before hadronizing

$$\tau_{top} \sim 4 * 10^{-25} s\ ,\ \ \Gamma \approx 1.5\ \text{GeV} >> \Lambda_{QCD} \sim 200\ \text{MeV}$$

- No spectroscopy like other heavy flavor
- Top momentum and spin transferred to decay products

Standard Model:
t→Wb ~ 100%





Main "usable" top event topologies:

- tt → lνlνbb di-lepton 5% (e+μ)
- tt → lνqqbb lepton+jets 30% (e+μ)
- tt → qqqqbb all hadronic 45%

Outline

1. The experimental environment:
   - The Tevatron
   - The Collider Detector at Fermilab

2. Experimental challenges in top physics:
   - tracking, vertices and b-jet identification
   - jet reconstruction and energy measurement
   - understanding W+jet background

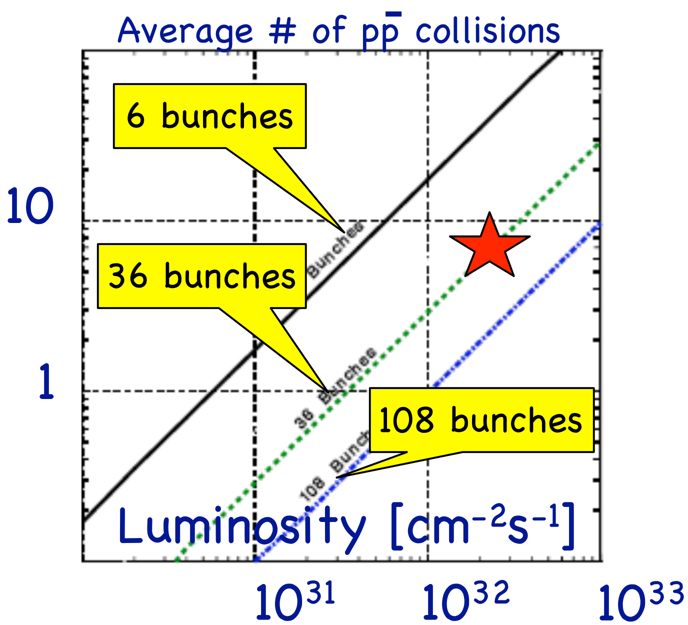
3. Top physics in the lepton+jet channel with 700 pb^{-1}:
   - the top pair production cross section
   - the top mass

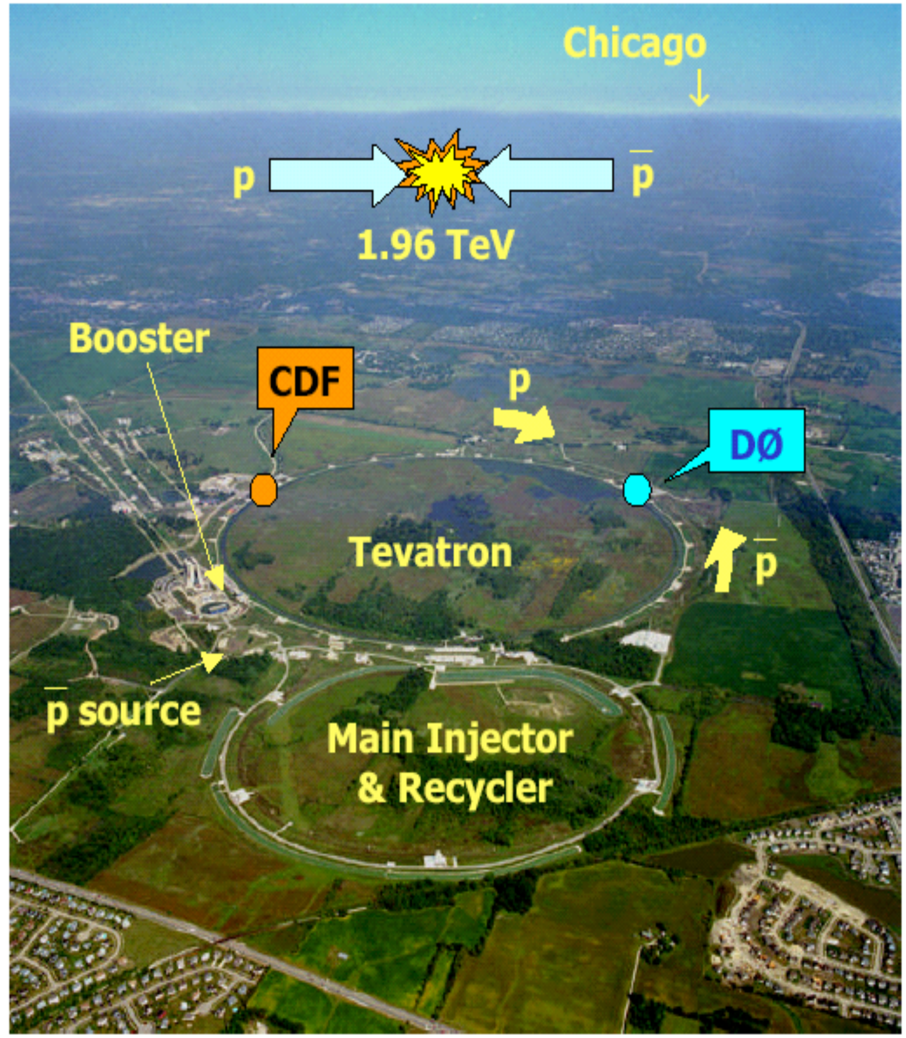
4. Single top and top resonant production searches

5. Summy: plan for top physics with $\approx 2fb^{-1}$

The TeVatron Collider

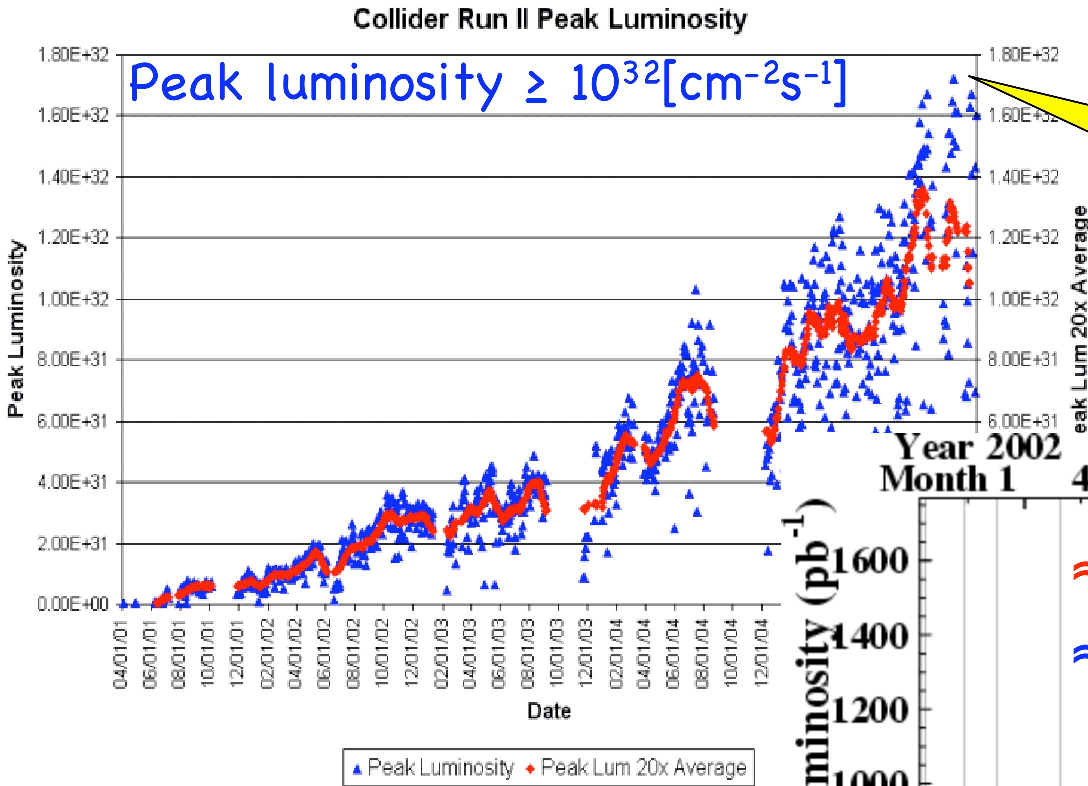
- p-pbar collisions
  $\sqrt{s}$=1.96 TeV (RunI 1.8)
- 36 bunches, 396 ns
- record peak Lum. 1.8x10^{32}[$cm^{-2}s^{-1}$]
  - ✓ Recycler
- 1.7 <interaction>/bunch crossing
- ≈ 25 pb^{-1}/week



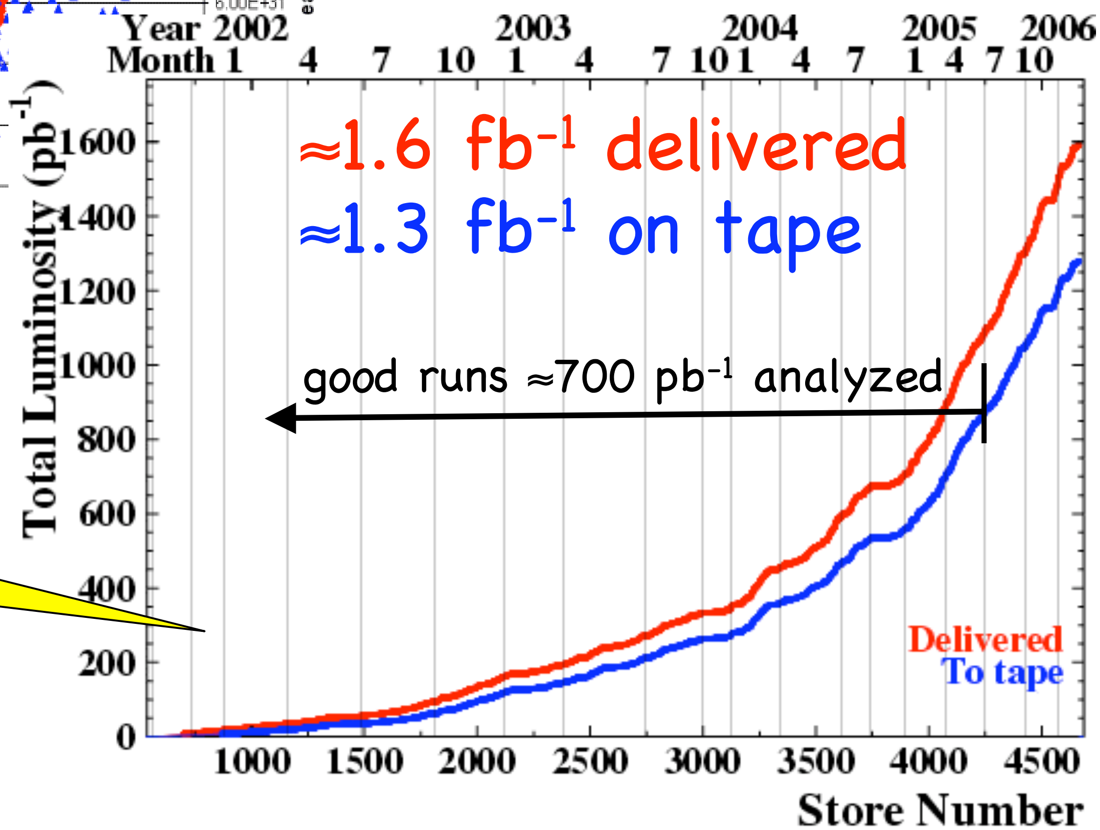


4 fb^{-1} expected by 2009. Electron cooling on track could get 8 fb^{-2} 2009

Luminosity Summary



1.7×10^{32} [$cm^{-2}s^{-1}$]



≈1.6 fb^{-1} delivered

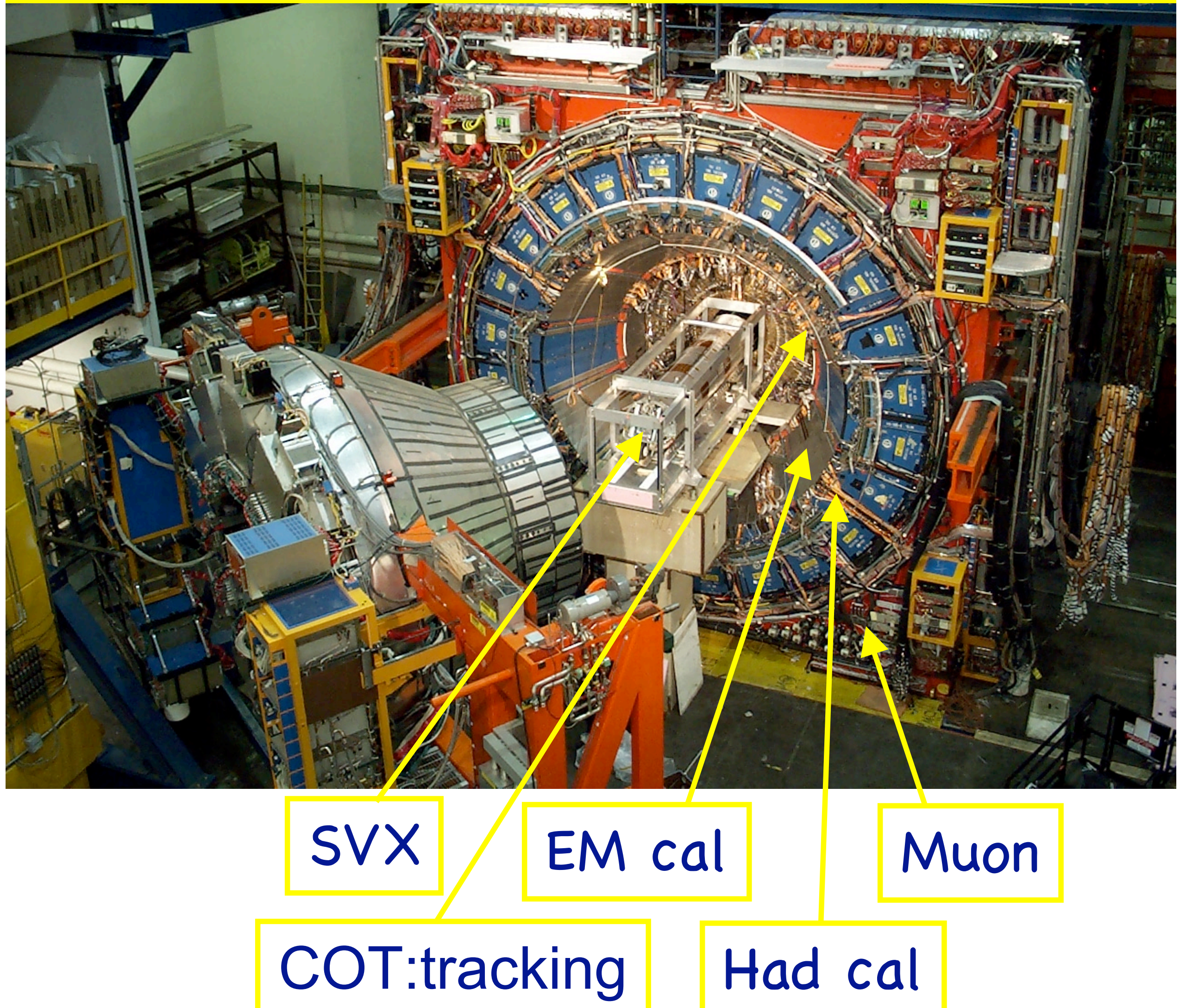
≈1.3 fb^{-1} on tape

Data taking efficiency≈85%

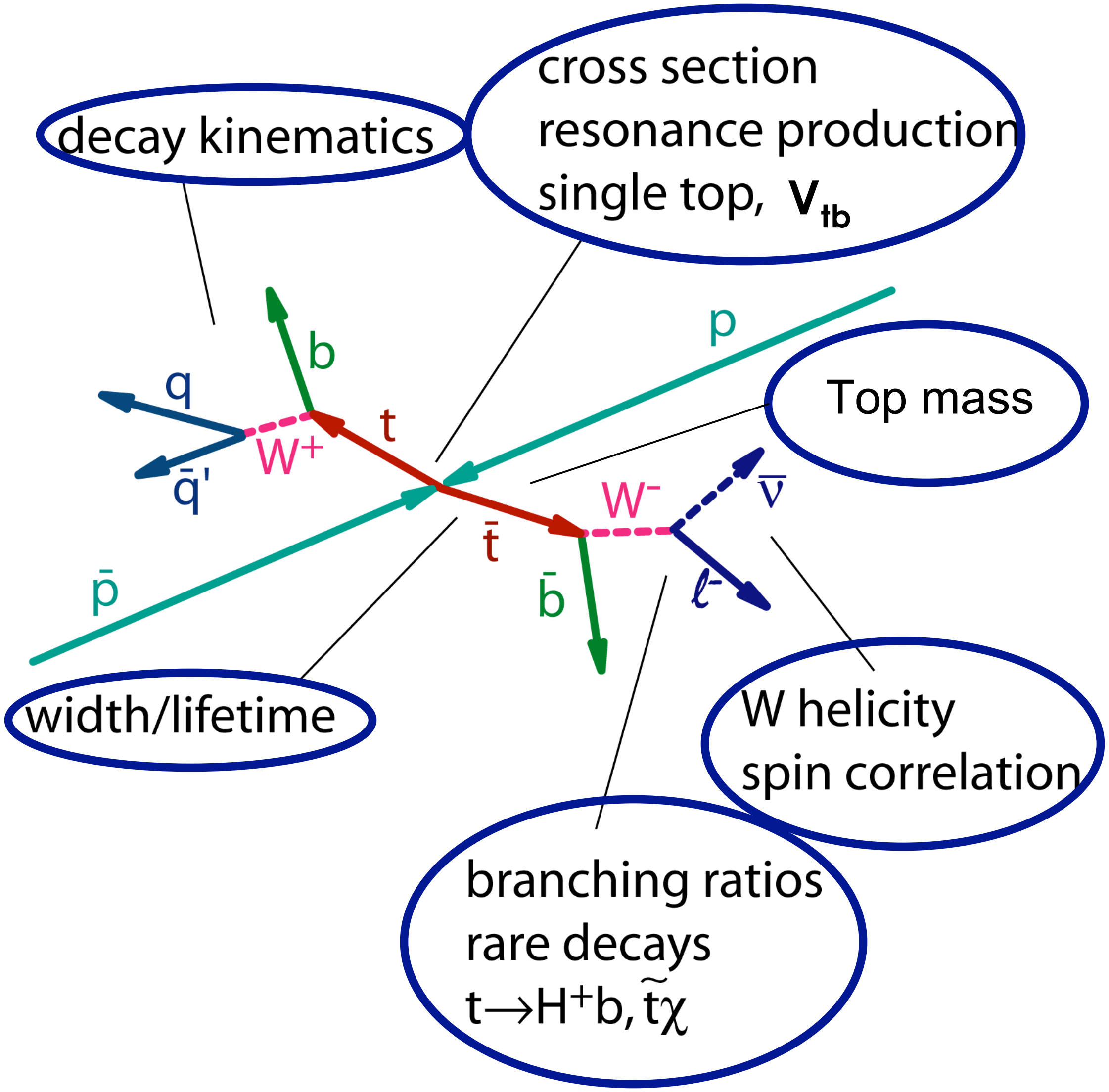
Central Detector at Fermilab

Multi-purpose detector:
precision measurements & search for new physics

- Silicon detector (SVX):
- COT: drift chamber
  - Coverage: $|\eta|<1$
  - $\sigma_{Pt} / P_T \sim 0.15\% \, P_T$
- Calorimeters:
  - Central, wall, plug
  - Coverage: $|\eta|<3.6$
  - EM: $\sigma_E / E \sim 14\% / \sqrt{E}$
  - HAD: $\sigma_E / E \sim 80\% / \sqrt{E}$
- Muon: scintillator+chamber
  - muon ID up-to $|\eta|=1.5$



SM physics & beyond in top quark



Top quark:

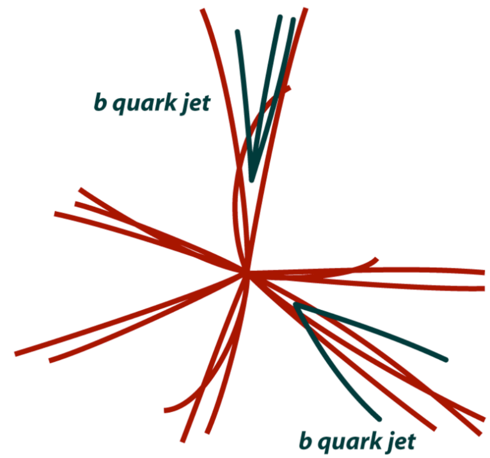
- Top production rate
- Top mass
- Single top production

Top quark properties:

- Top production rate
- W helicity in top events
- Anomalous couplings
- $|V_{tb}|$
- New physics?

...on the right path but we need more statistic

Top experimental signature



Final State (jepton+jet): lepton, neutrino plus 4jets

- ✓ High-pt central electron/muon triggers
- ✓ High pt electron or muon with Pt > 20 GeV
  - Isolated

    Electron: EM cluster in calorimeter with matched track

    Muon: track matched to hits in muon chambers, MIP ionizing energy in calorimeter
- ✓ Large missing Et >20 GeV
- ✓ Leading 4 jets
  - Reconstructed with cone algorithm (0.4) using calorimeter towers
  - $|\eta|<2.0$

Acceptance ≈ 5% including BR

Challenges:

b-tagging algorithm

Jet energy resolution

W+jets & QCD

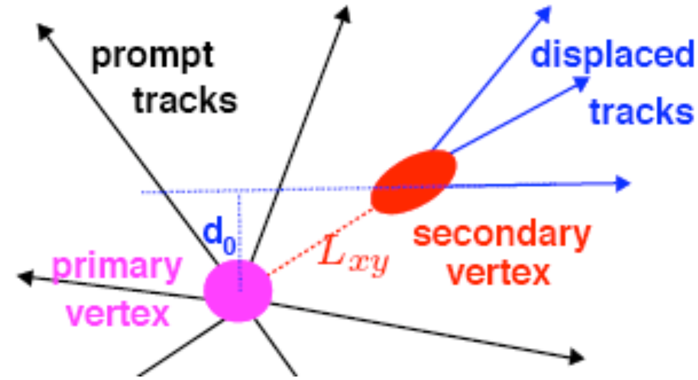
Backgrounds

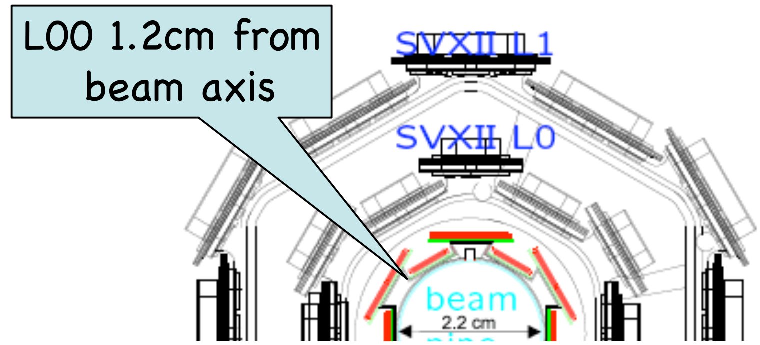
B-tagging: tracking

Identify heavy flavor jet by reconstructing displaced secondary vertices wrt the primary vertex. B $c\tau \approx 460[\mu m]$

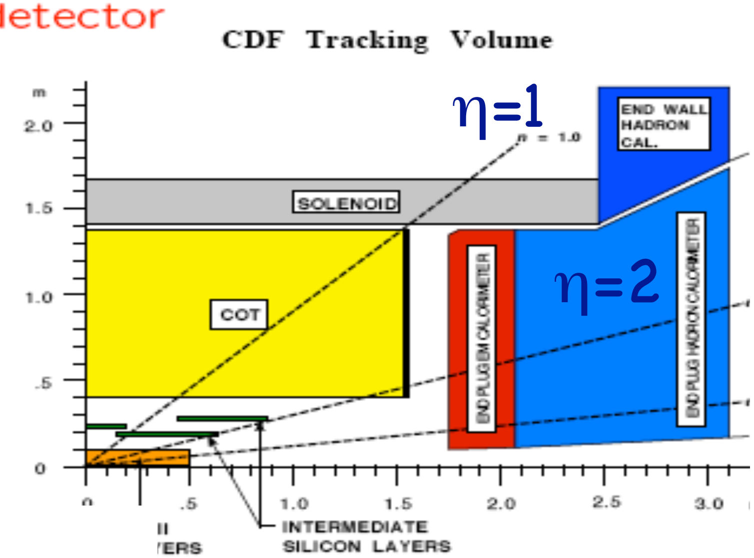
Ingredients for a good SecVtx tagging:

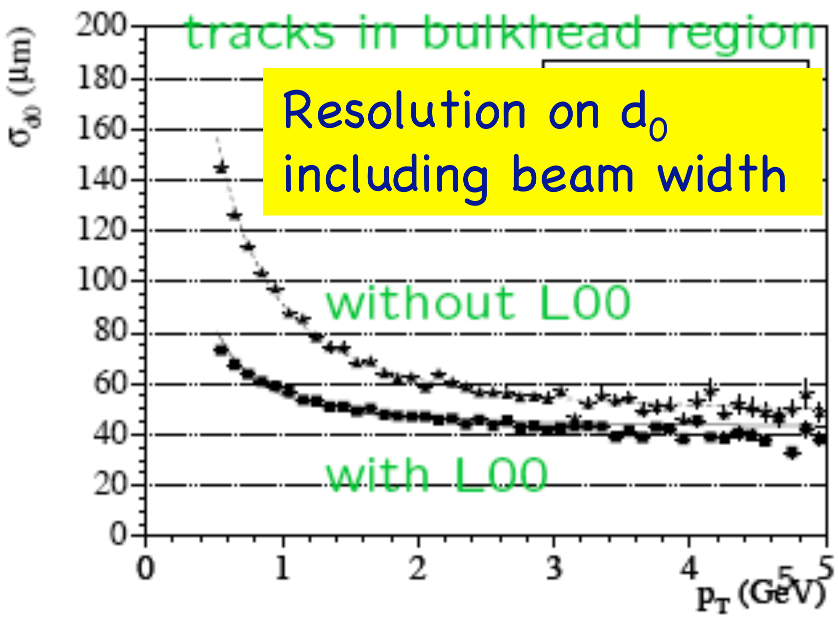
- efficient tracking reconstruction
- resolution on impact parameter ($30\mu m$)
- resolution on primary vtx ($10\text{->}30\mu m$)
- efficient reconstruction of secondary vertices inside a jet





detector



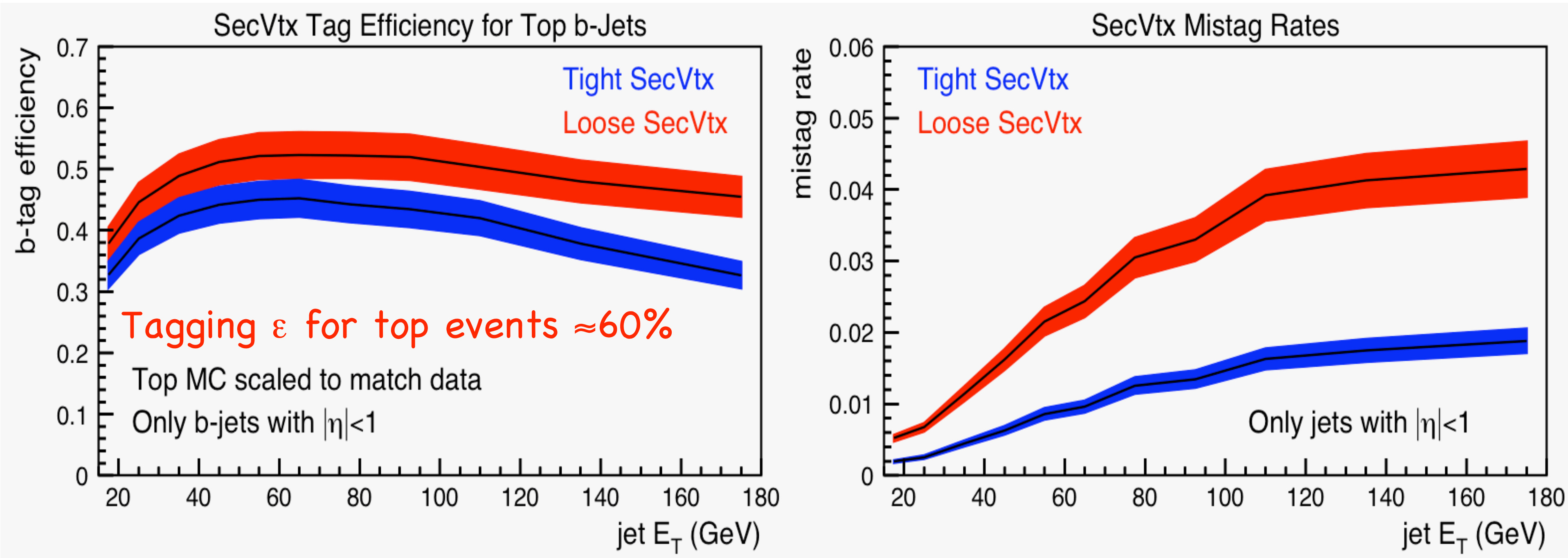


B-tagging

SecVtx b-tagging:
- ✓ Identify displaced vtx inside a jet

Jet probability b-tagging:
- ✓ Probability that jet tracks come from primary vertex

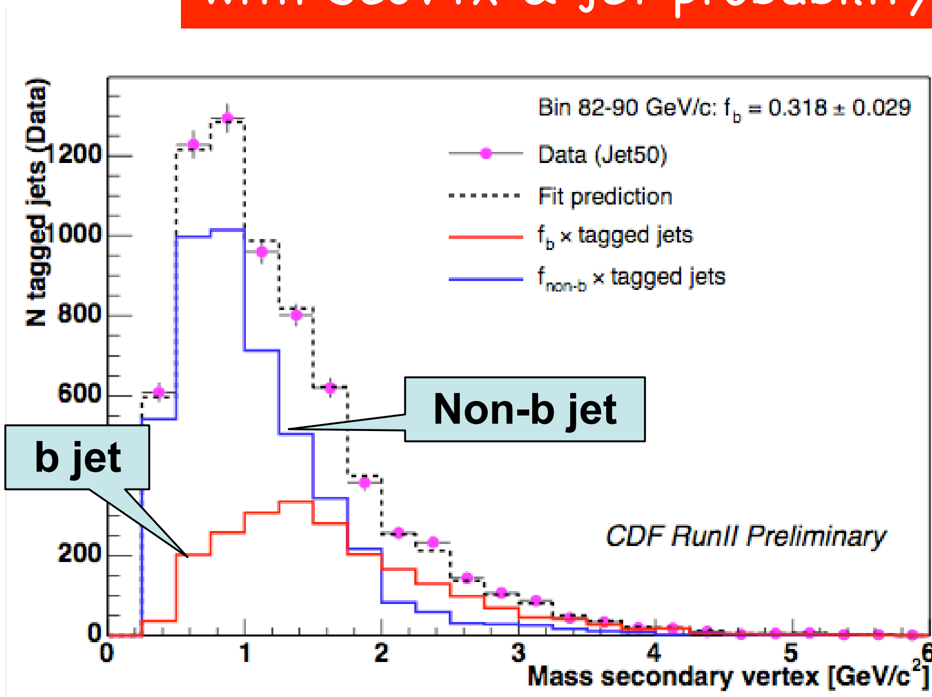
Soft lepton b-tagging:
- ✓ Identify leptons($e\mu$) from HF decay

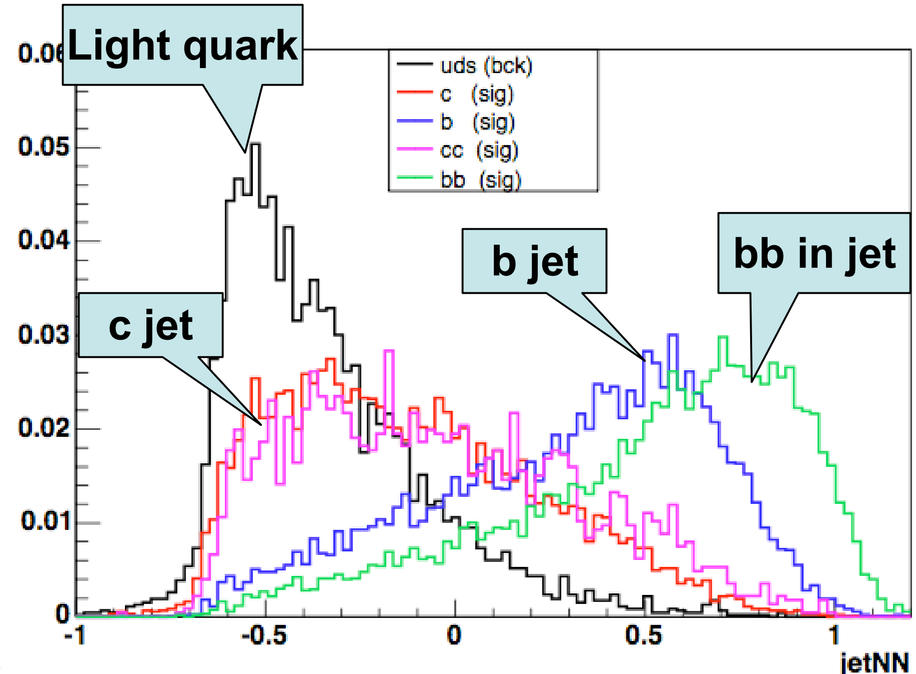


SecVtx is the algorithm used for the results presented here.

B-tagging: advanced algorithm

In progress: use jet properties, secondary vtx mass, ... along with SecVtx & jet probability to disentangle HF from light F



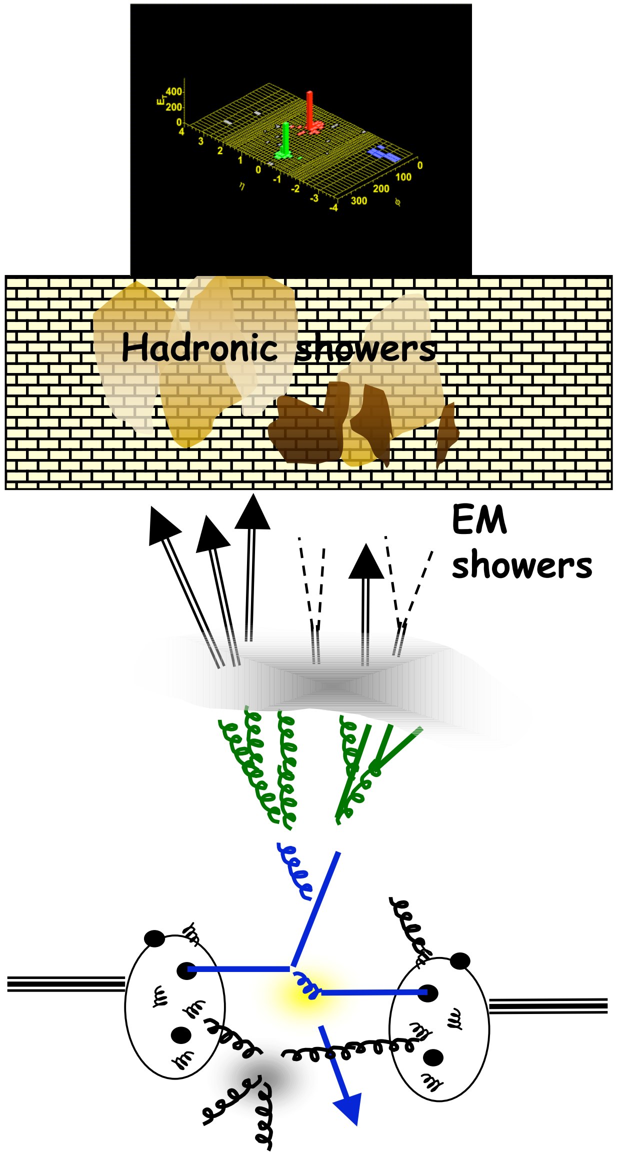


Keeping the same misstag rate the efficiency increases by ≈10%

- more efficient selection of double tagged top events (purest sample)
- NN out could be used as a b-jet pdf in a likelihood

Jet corrections

Jets are collimated sprays of hadrons originating from the hard scattering



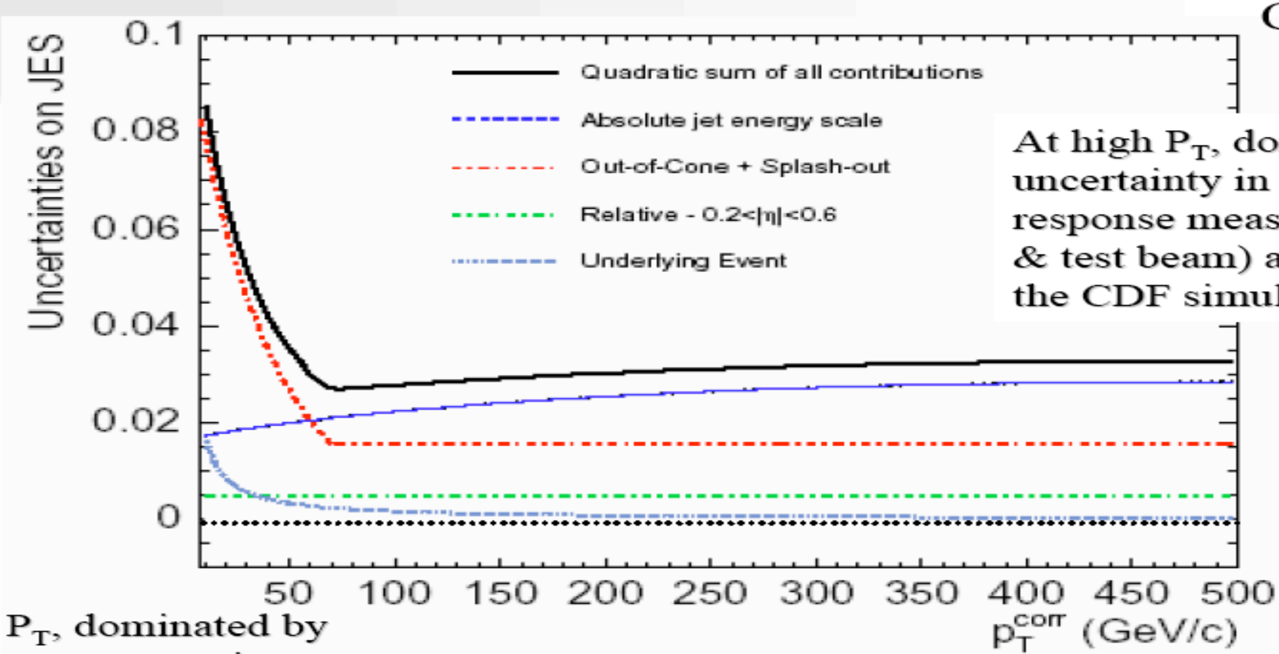
- ✓ Calorimeter jets: complex detector behavior
  - must correct for detector cracks, efficiency
  - must correct for pile-up interactions (3.6 average interaction @ $10^{-32}cm^{-2}s^{-1}$ (<1.7>)

- ✓ Hadron jets:
  - Correction to particle jets using dijet MC tuned for single particle E/P, material, and fragmentations:
  - underlying event subtraction

- ✓ Parton jets: model dependent correction
  - Gluon radiation, energy loss
    - Monte Carlo model based

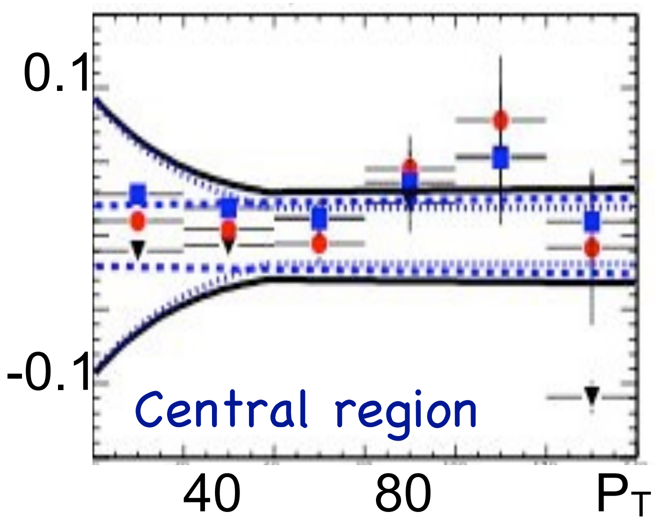
Jet correction systematic

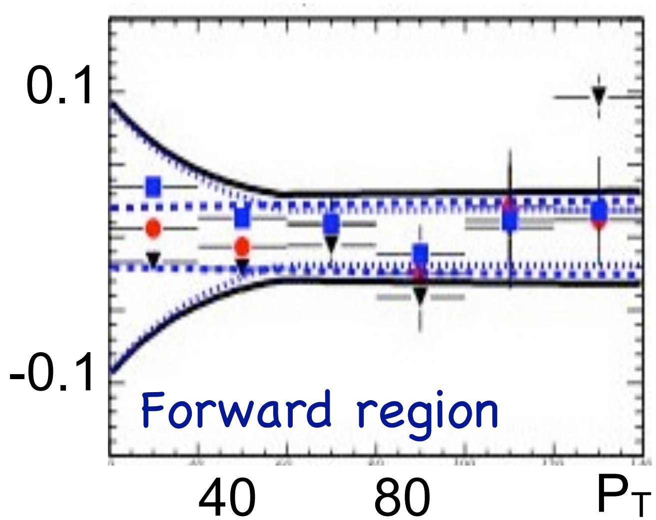
Central jets

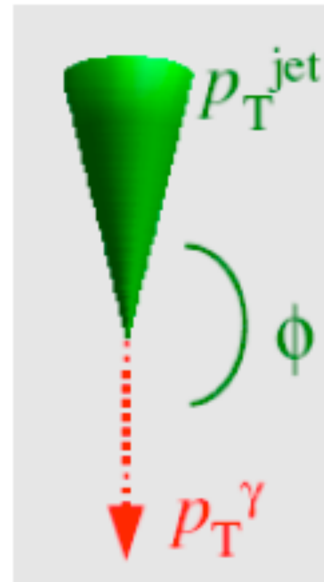


At high P_T, dominated by uncertainty in single particle response measurements (in-situ & test beam) and tuning of the CDF simulation

At low P_T, dominated by out-of-cone uncertainty (physics modeling uncertainty)







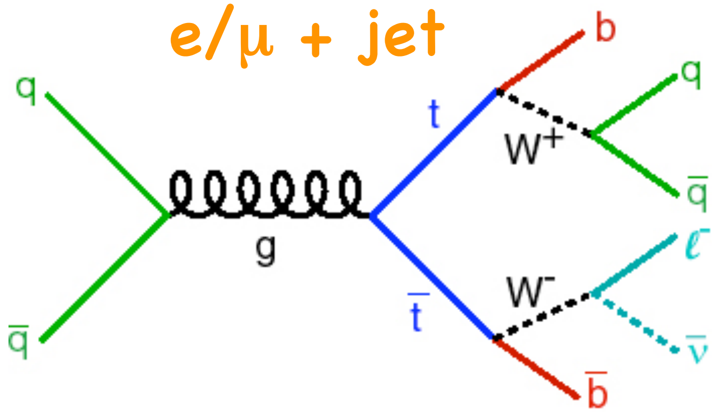
γ+jets, di-jet, Z+jets are used to cross check the jet energy corrections.

Measuring top quark pair cross section

One of the first things to measure is the top pair production rate.

$$\sigma(t\bar{t}) = \frac{N_{events} - N_{background}}{\mathcal{L}uminosity * \varepsilon}$$

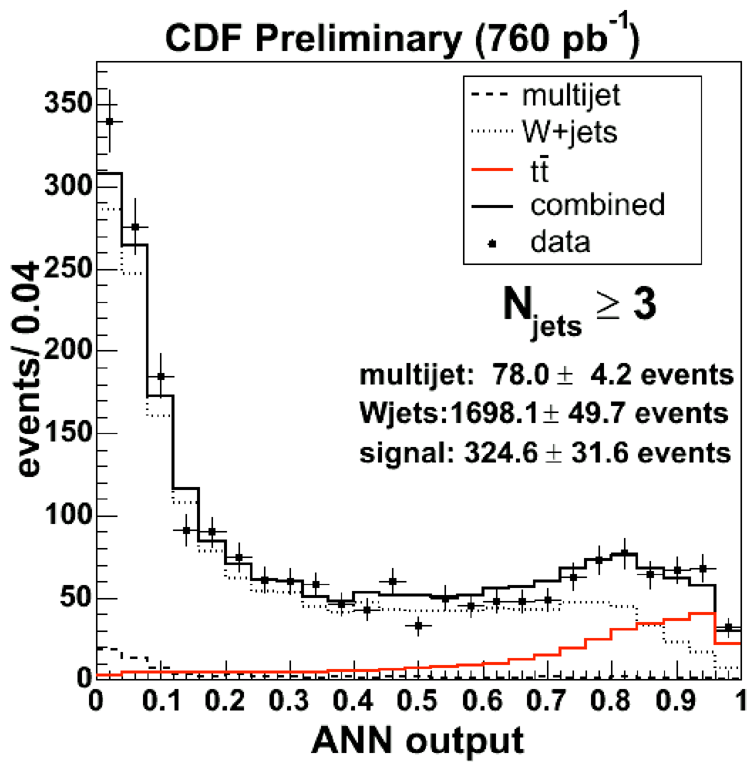
Golden channel: e/μ + jet

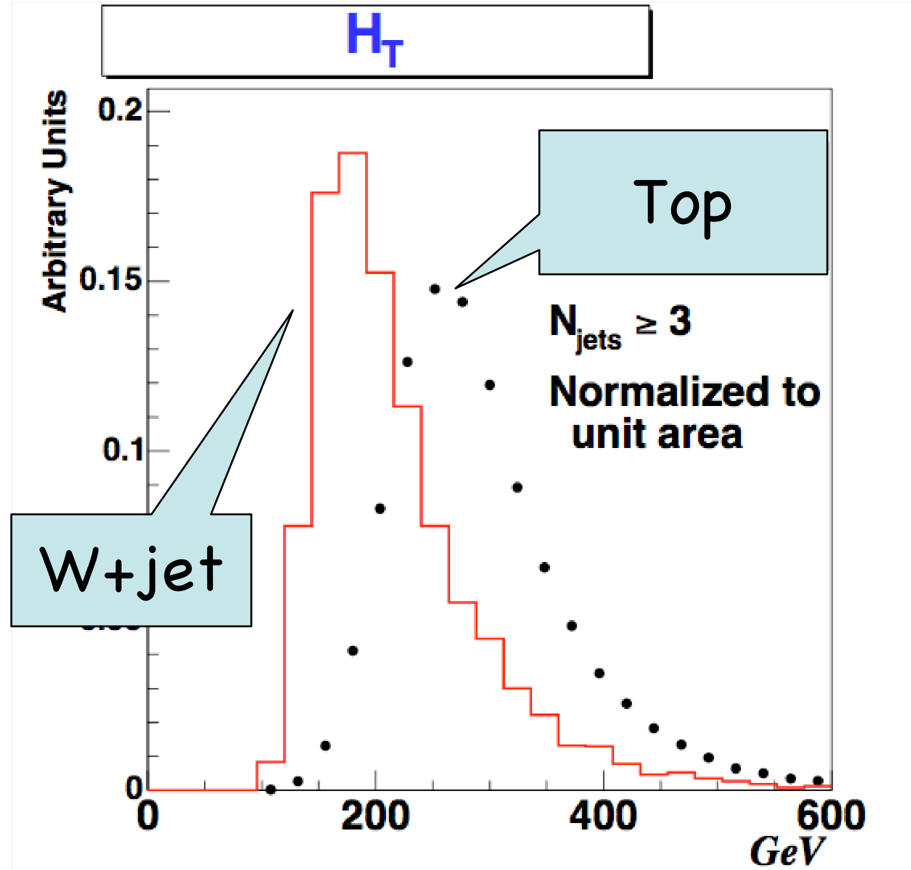


- ✓ 1 isolated e/μ p_T>20 GeV/c
- ✓ at least 3 jets p_T>15 GeV/c
- ✓ MET>20 GeV

Lepton+jets cross section - kinematic fit

Need more discrimination against same final state from W+jets processes!





<u>Kinematic event observables</u>

- Decay products of top more energetic and central than W+jets
- Combine kinematic observables in NN
- Fit observed data to expected distributions from signal and backgrounds

top cross sections in l+jets

Kinematic fit

σ (>3jet) = 6.0 ± 0.6(stat.) ± 0.9(sys.) pb

σ (≥4jet) = 5.8 ± 0.8(stat.) ± 1.3(sys.) pb

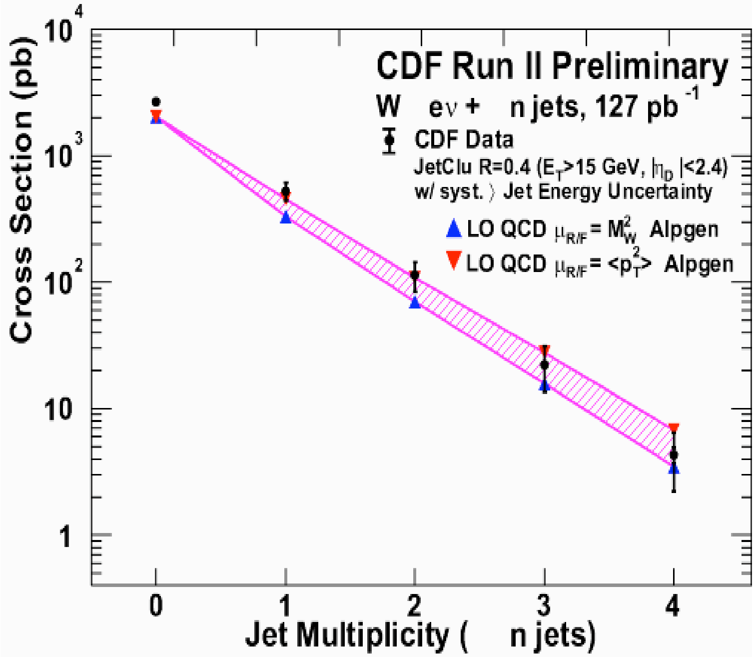
Source	ANN (%)
Jet Energy Scale	8.3
W+jets Background	10.2
QCD Background	1.3
$t\bar{t}$ generator	2.6
$t\bar{t}$ PDF	4.4
$t\bar{t}$ ISR/FSR	2.2
Lepton ID	2.4
Luminosity	5.8
Total	15.7

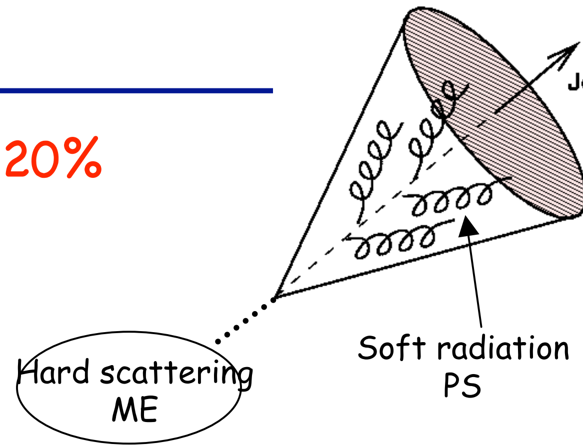
Why the W+jet background gives such a large systematic:

- what is the status of MC
- which are the plan for improvement

Monte Carlo simulation

LO calculation rate uncertainty 50%, shape 10-20%

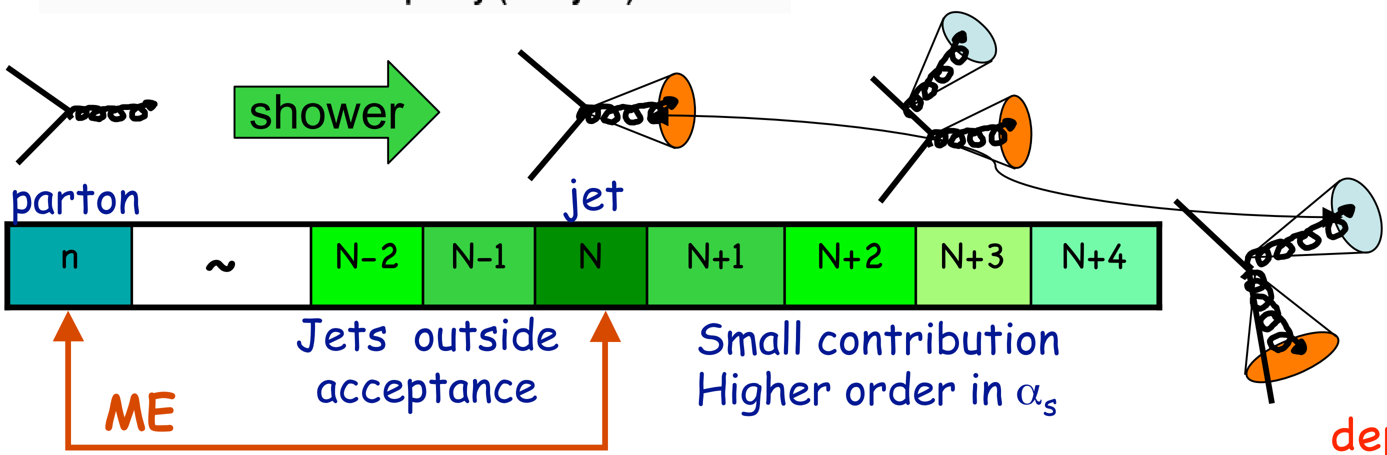




Naïve: W+n p (ME)+(PS) ~ W + ≥ N jet

W+(n+1) p (ME)+(PS) ~ W + ≥ N+1 jet

...



2 topologies ~ O(a)
Same jet multiplicity

double counting

dep. on parton-level cuts

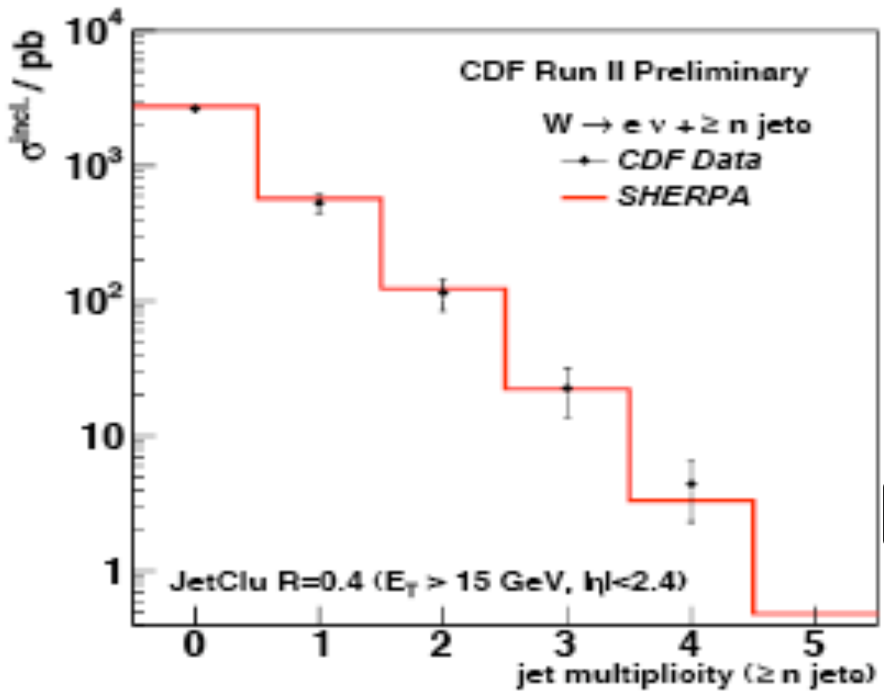
New merging tools

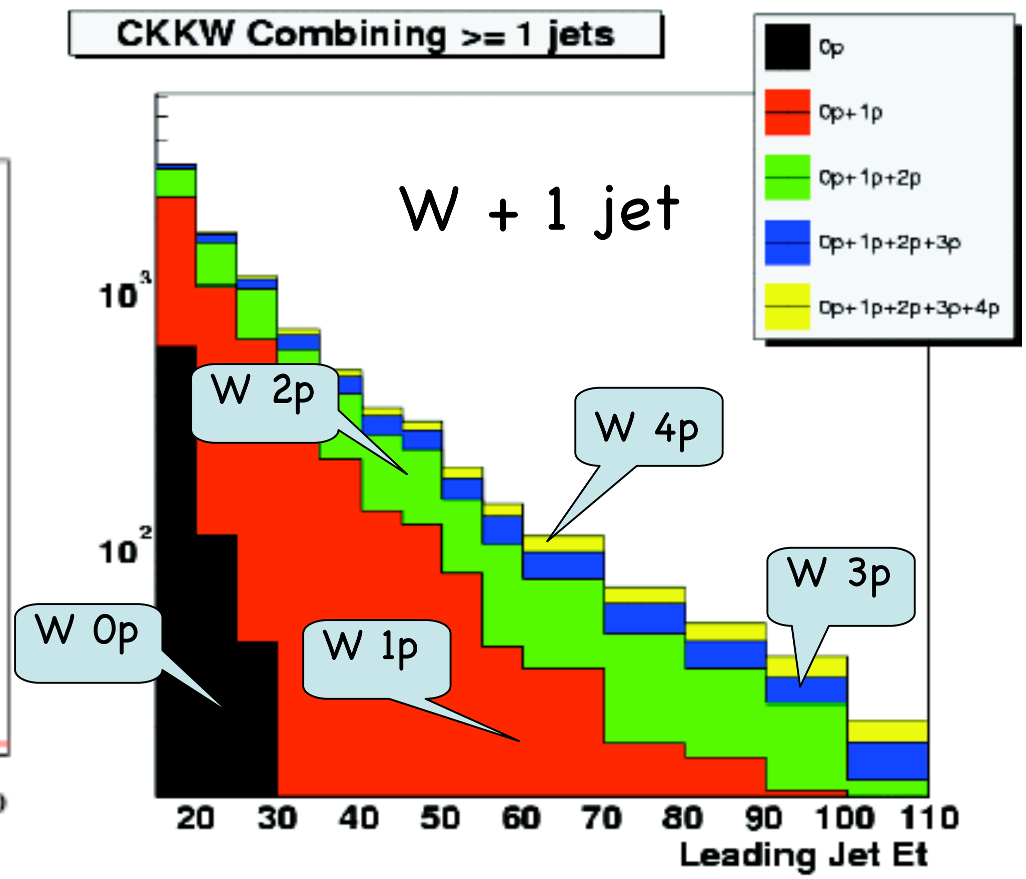
Separate multijet phase-space
- Matrix element domain
- Parton shower domain

LO ME calculation interfaced with parton shower MonteCarlo

MLM's matching
Michelangelo Mangano

CKKW prescription
Catani, Krauss, Kuhn, Webber



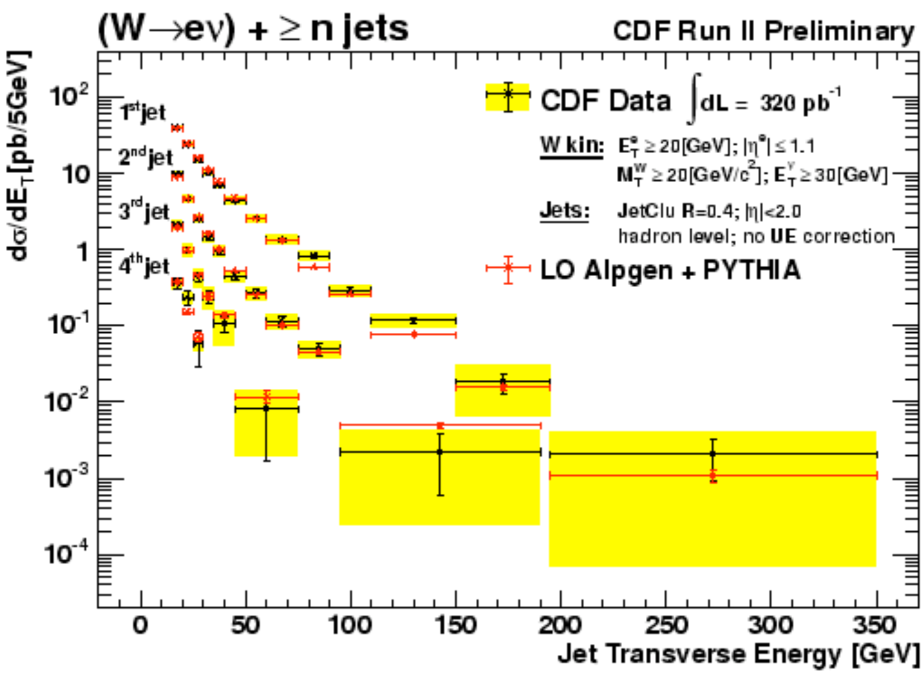


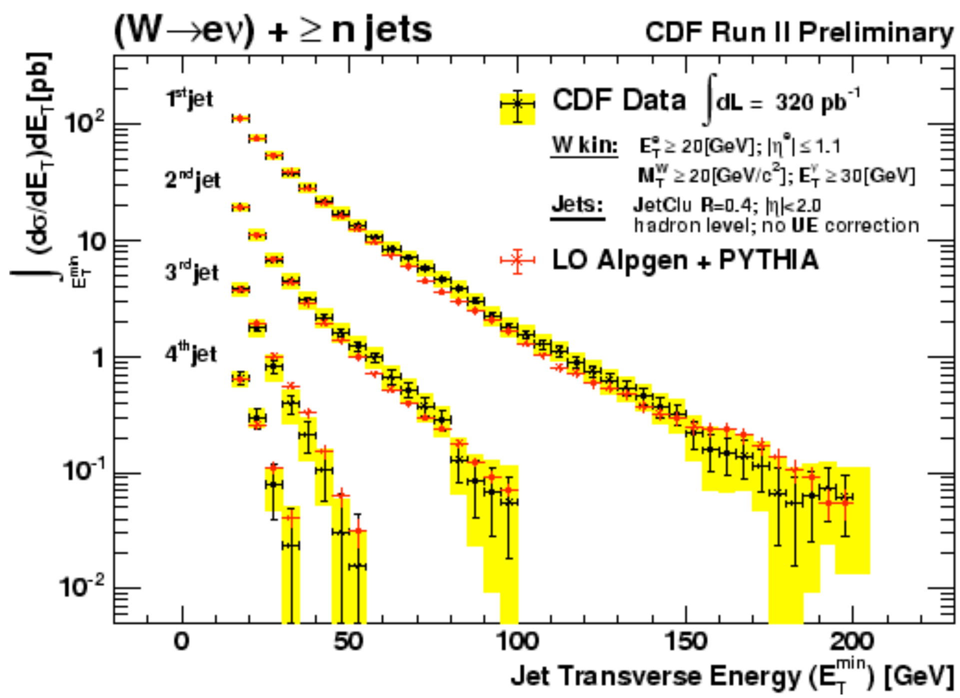
Have to be validated & tuned on data!!!

W+jets cross section

Differential xsec wrt jet E_T in each of the 4 W+ n jet inclusive samples

Integrated xsec wrt jet E_T in each of the 4 W+ n jet inclusive samples





This cross sections will allow to make an effective tuning of new leading order Monte Carlo generators -> reducing the MC uncertainties on top & searches

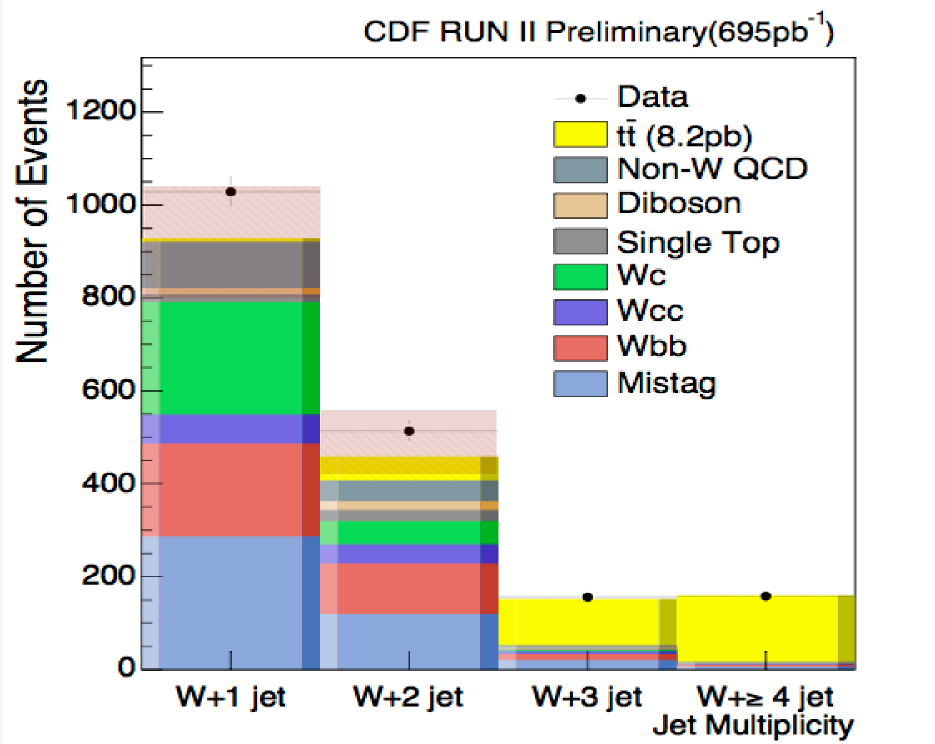
Lepton+jets with b-tagging

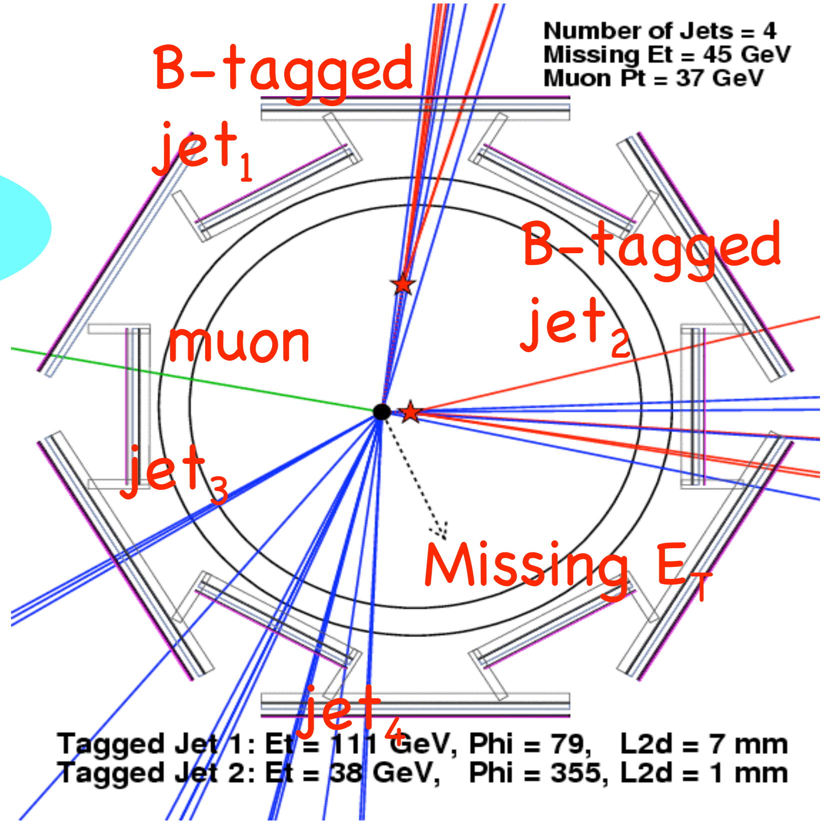
$$N_{data}^{W+jets} \times \frac{N_{MC}^{W+HF}}{N_{MC}^{W+jets}} \times \varepsilon(\mathrm{b-tag})_{MC}^{W+HF}$$

MC fraction of W+jets from HF

Data number of W+jets events before b-tag
Correct for non-W & ttbar

b-tag efficiency for W+HF MC
Scale by data/MC b-tag ratio





top cross sections in l+jets

Kinematic fit	SecVtx b-tagging
σ (>3jet) = 6.0 ± 0.6(stat.) ± 0.9(sys.) pb	σ (≥1tag) = 8.2 ± 0.6(stat.) ± 1.0(sys.) pb
σ (≥4jet) = 5.8 ± 0.8(stat.) ± 1.3(sys.) pb	σ (≥2tag) = 8.8 ± 1.2(stat.) ± 1.3(sys.) pb

Source	ANN (%)
Jet Energy Scale	8.3
W+jets Background	10.2
QCD Background	1.3
$t\bar{t}$ generator	2.6
$t\bar{t}$ PDF	4.4
$t\bar{t}$ ISR/FSR	2.2
Lepton ID	2.4
Luminosity	5.8
Total	15.7

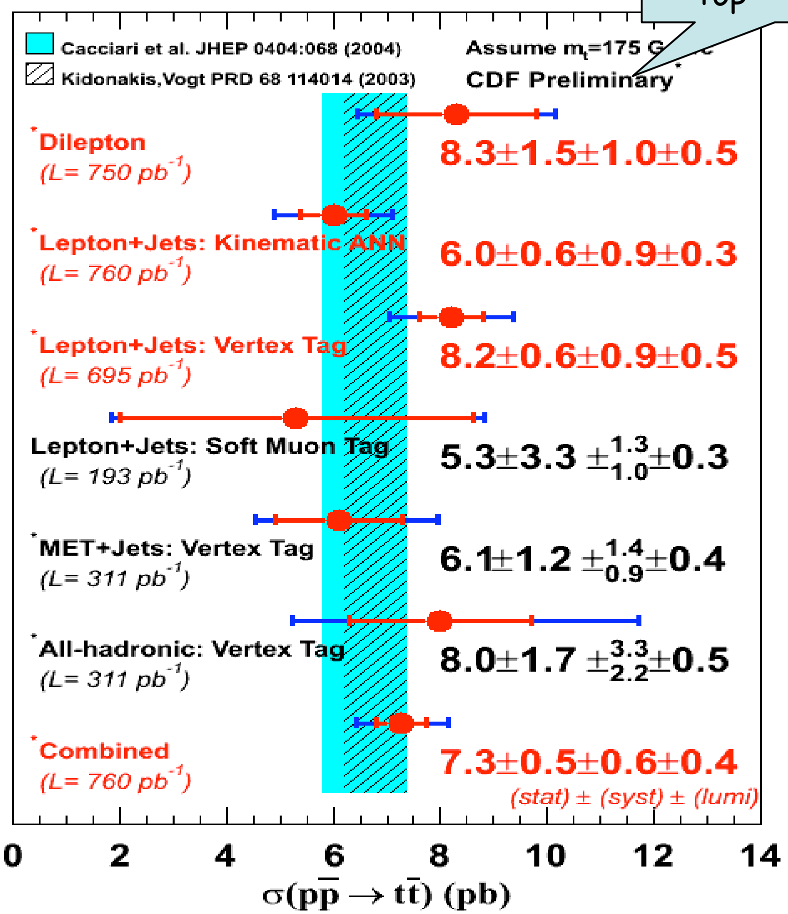
Source	Systematic (%)
b-tagging	6.5
Luminosity	6.0
PDF	5.8
Jet Energy Scale	3.0
ISR/FSR	2.6
Lepton Identification	2.0
Total	11.5

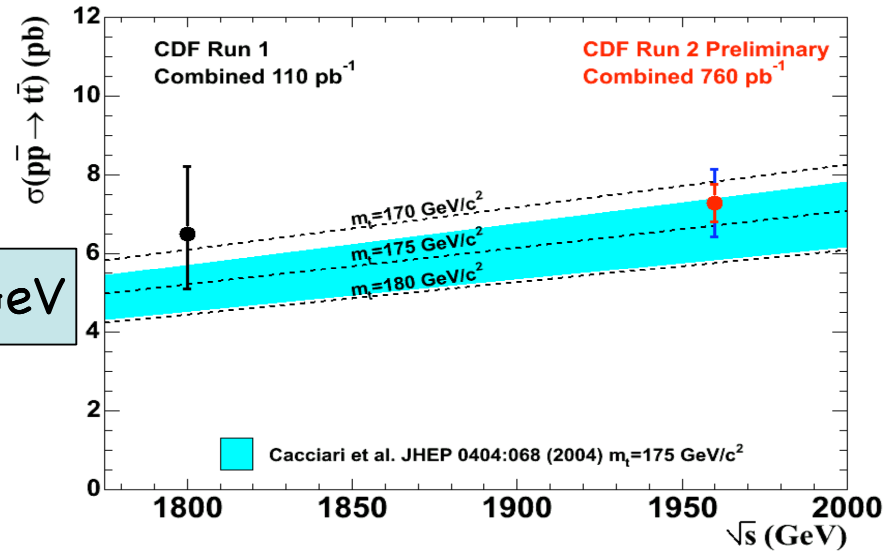
Largest systematic is the b-tagging scale factor data-MC efficiency (6.5%).

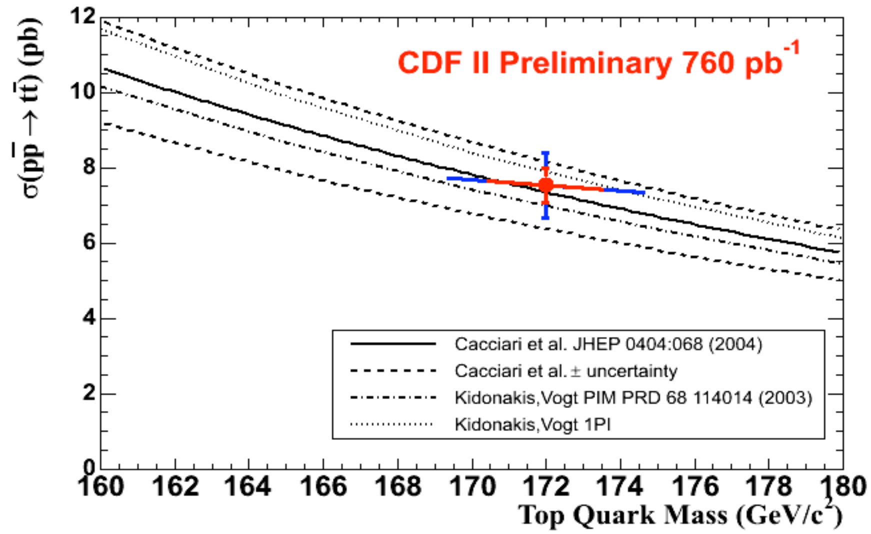
Top quark pair production

Many different approaches to measuring the top cross section, allowing us to carefully cross check the results, and look for anomalies.

M_{top}=175GeV



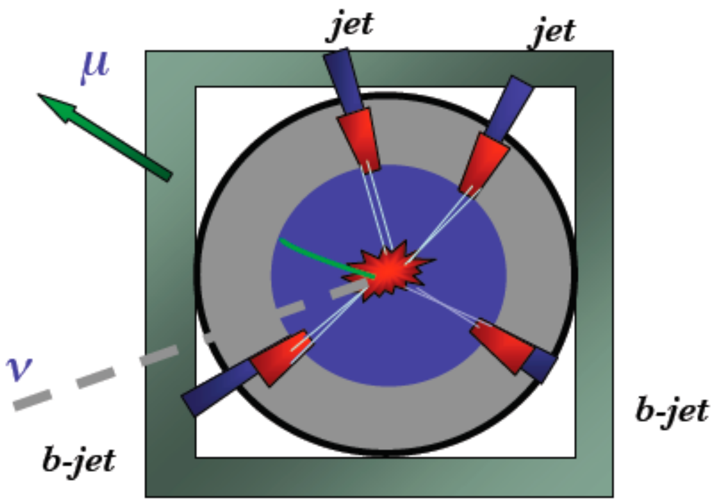




Top pair production cross section measured at 10%

How to measure the mass

How do we know how much mass a particle had?



we can't just put the pieces back together again!

Lost information:

- neutrinos have escaped the detector
- Quarks have radiated, showered and hadronized
- jet to parton association

misinformation:

- Background processes mimic top

Detector effects:

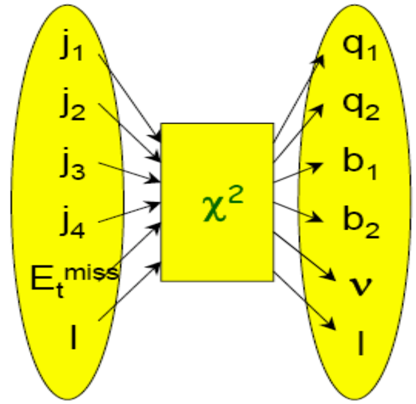
- Lepton identification is good but not perfect
- Jet energy scale and jet mass resolution
- B-tagging and jet to parton association

Solution:

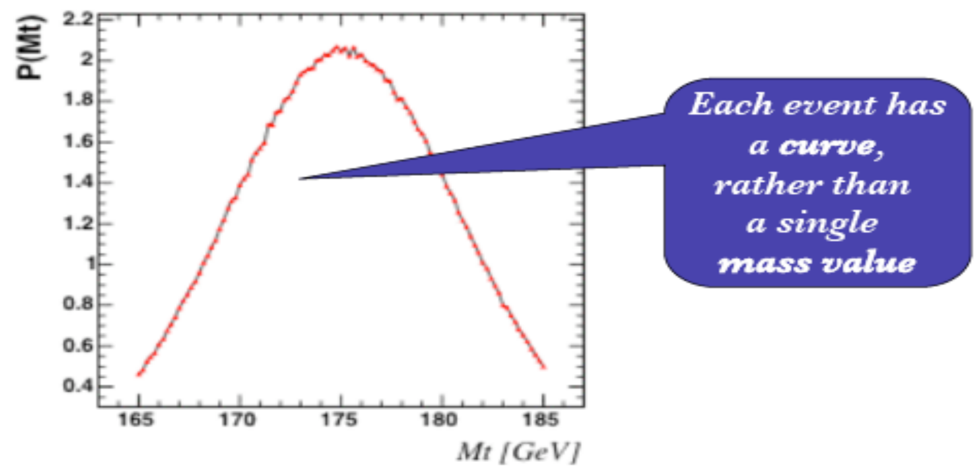
Lepton + jets:
- 4 jet resolutions
- parton-jet associations:
  - 24 (no-btag)
  - 12 (1-btag)
  - 4 (2-btag)
- one missing neutrino

Dilepton:
- 2 jet resolutions
- parton-jet associations (2)
- two missing neutrinos

All Hadronic:
- 6 jet resolutions
- parton-jet associations:
  - 90 (no-btag)
  - 30 (1-btag)
  - 6 (2-btag)



Choose an estimator of M_{top}



Construct a probability curve P(Mt) for each event

⇓

Form joint probability for all events

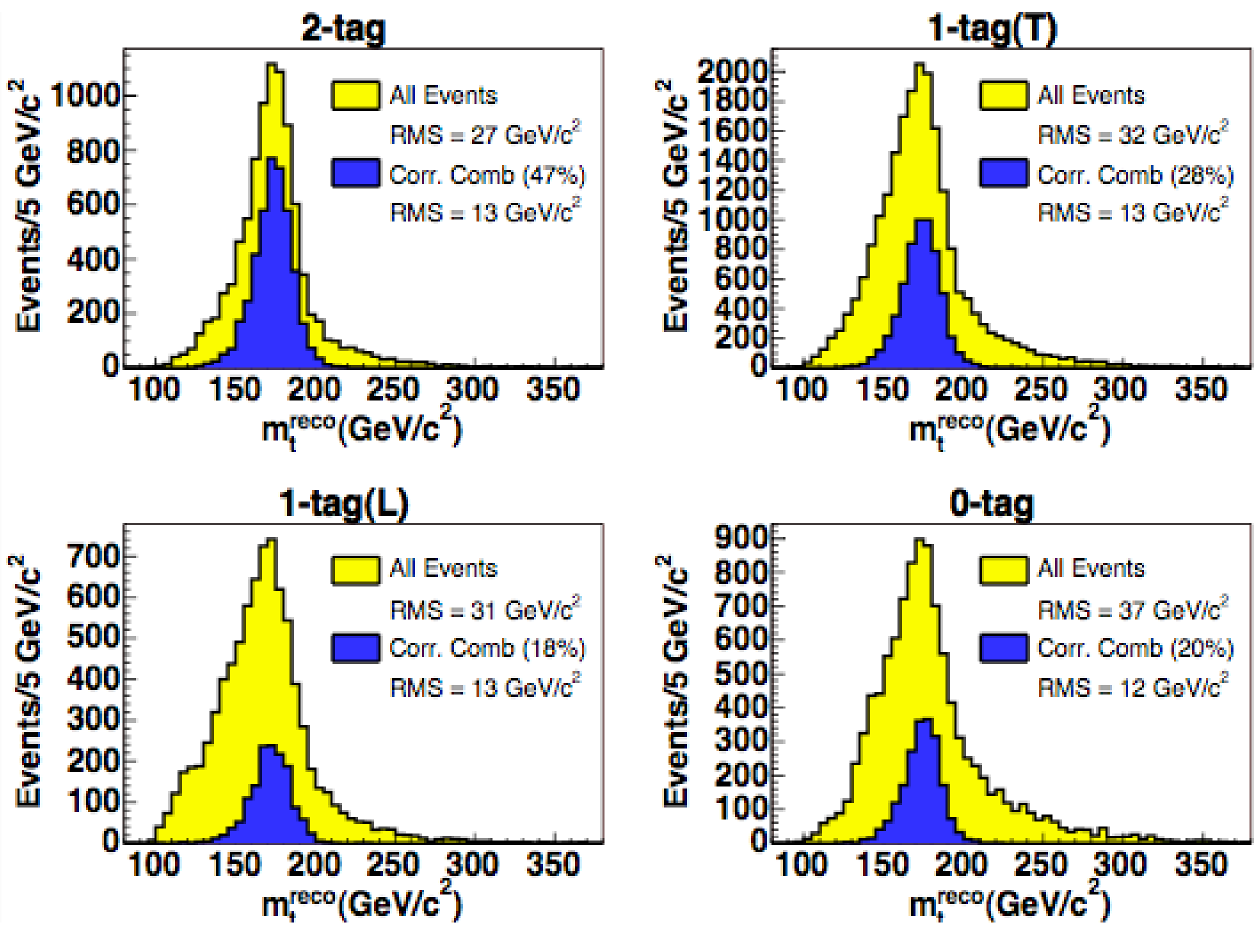
⇓

Choose most probable value!

Mass Fitter (event by event)

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

Top mass is free parameter



Constraint:

- event p_T balance
- $M_{jj} = M_W$
- $M_{l\nu} = M_W$
- $M_{t1} = M_{t2}$

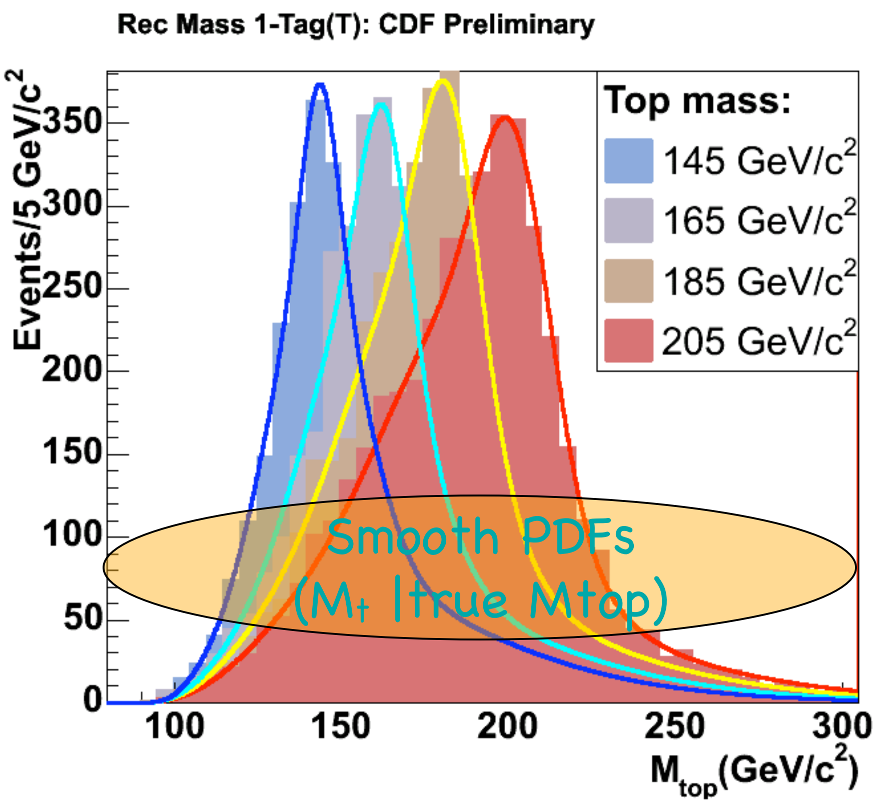
Vary:

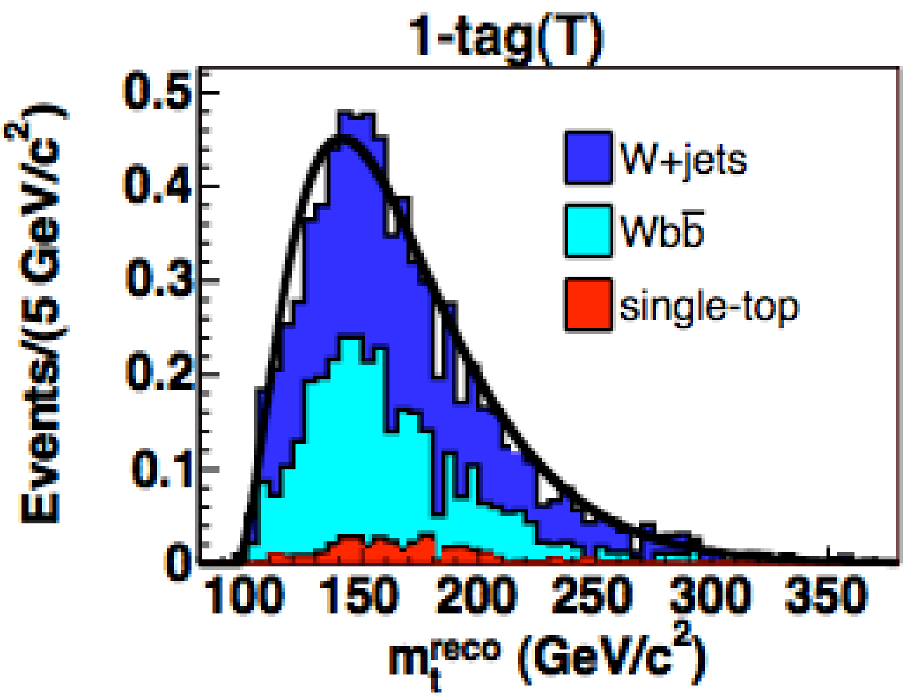
- Measurements within resolution
- parton-jet assignments
- two missing neutrinos

Construction the template for sign. & bkgd

- Samples: Herwig with Mtop = [130 to 230] GeV
- Get analytical functions (2 Gaussian + gamma) of reconstructed mass, M_t as a function of true mass, M_t
- linear depend. on M_t

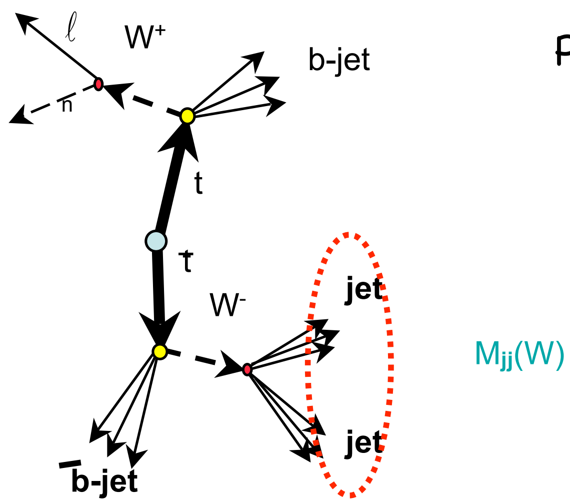
- 0tag: W+jets
- Tagged: W+HF, Mistag, fake-W, Single-top
- Shape: mostly by ALPGEN MC, cross-check with data

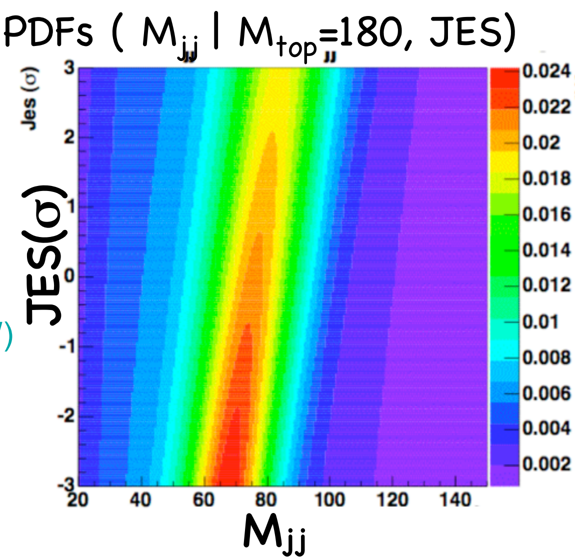


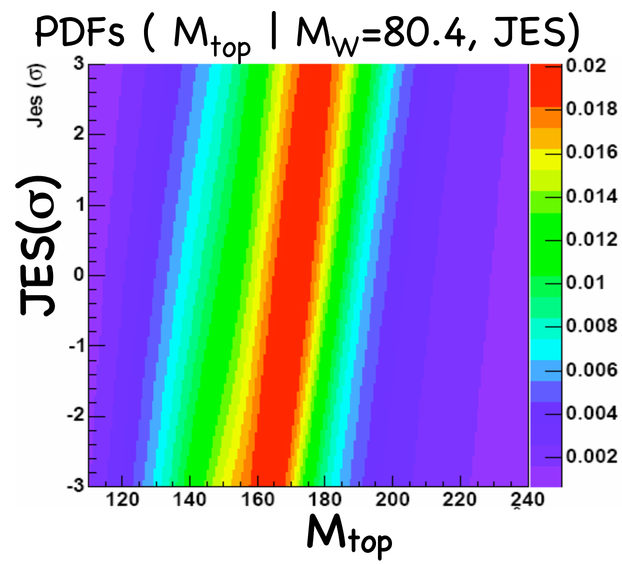


Simultaneous fit to JES and M_{top}

Reconstructed W mass is correlated to the jet energy scale in units of $\sigma(p_T,\eta)$ for the in situ jet calibration. M_{jj} largely independend on M_{top}







Mt templates

- Use same c2 fit
- Build templates for various M_{top}, JES
  - M_{top} : same mass range
  - JES : -3s to +3s : 1s defined by the standard JES uncert. (~3% in JES uncert., ~3 GeV in Mtop)
- Obtain PDFs (M_t | M_{top}, JES)

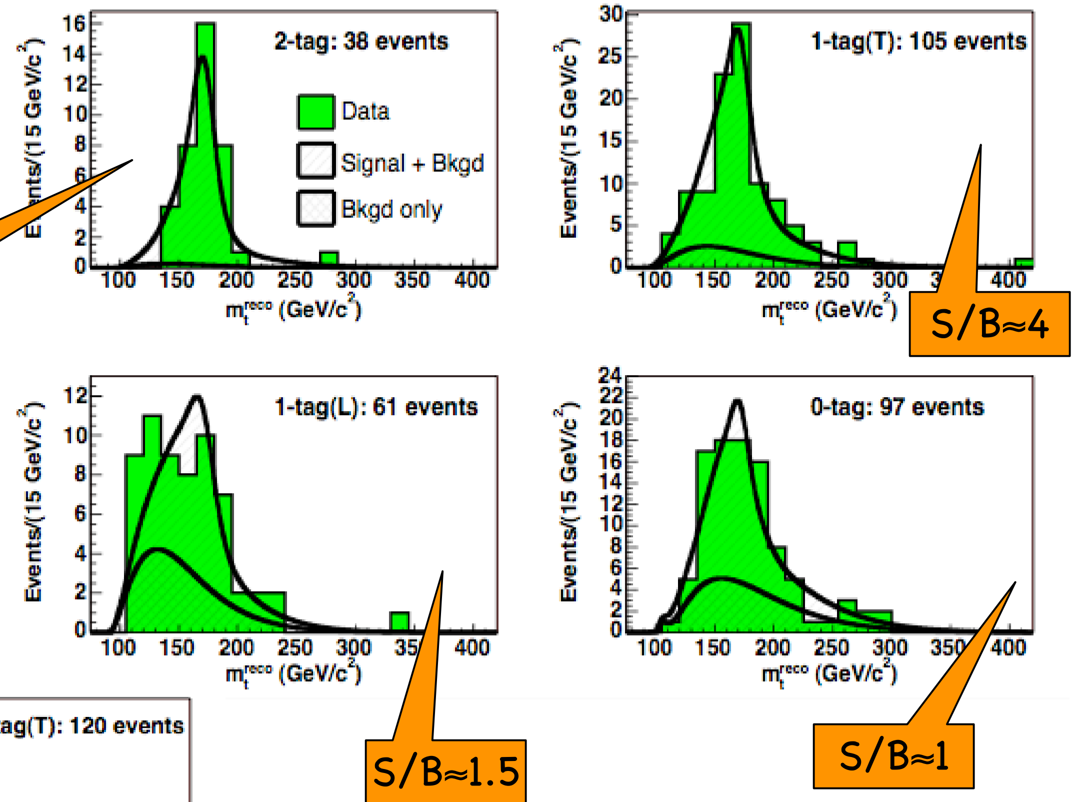
Mjj templates

- All pairs of non b-tagged jets from 4 leading jets are used. No χ^2 cut
- Templates are built in the same way Mt templates are made.
- Obtain PDFs (M_{jj} | M_{top},JES)

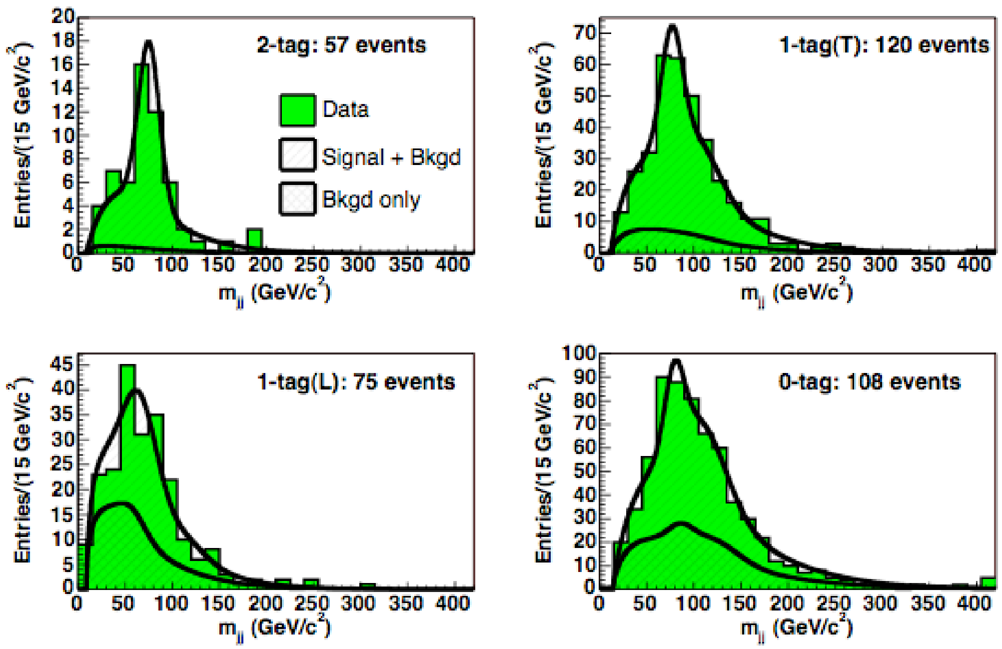
Template method

Reconstructed top mass in different event samples

Very pure Sample S/B≈10



Reconstructed W->jj mass in different event samples

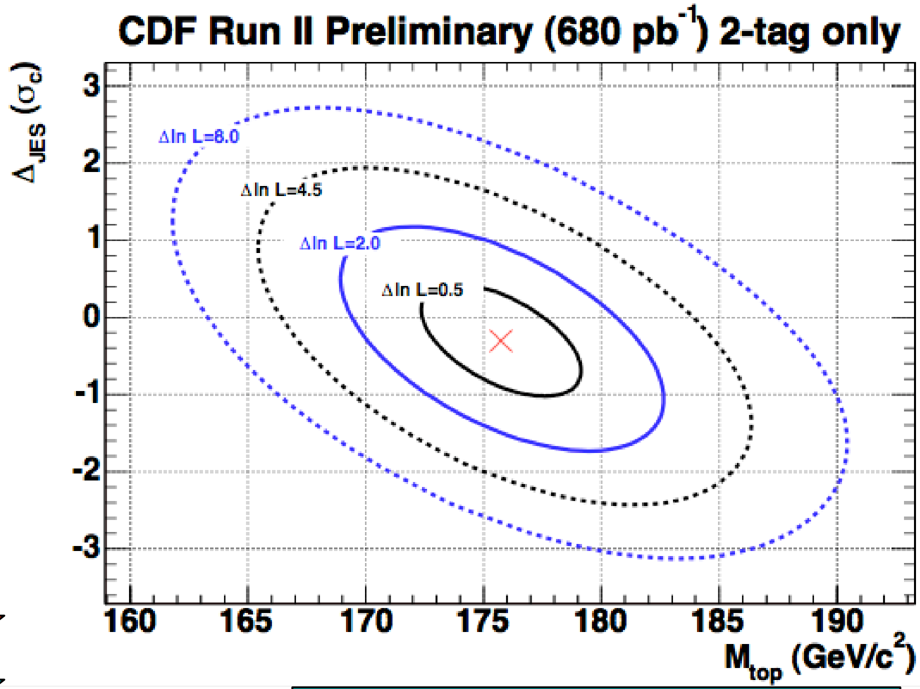


Sample	Expected sensitivity
0-tag	11%
1-tag(L)	9%
1-tag(T)	45%
2-tag	35%

Lepton + jets: results

$M_t = 173.4 \pm 1.7_{(Stat)} \pm 1.8_{(JES)} \pm 1.3_{(syst)}$ GeV/c²

$\Delta JES = -0.3 \pm 0.6\,\sigma$



Systematic breakdown

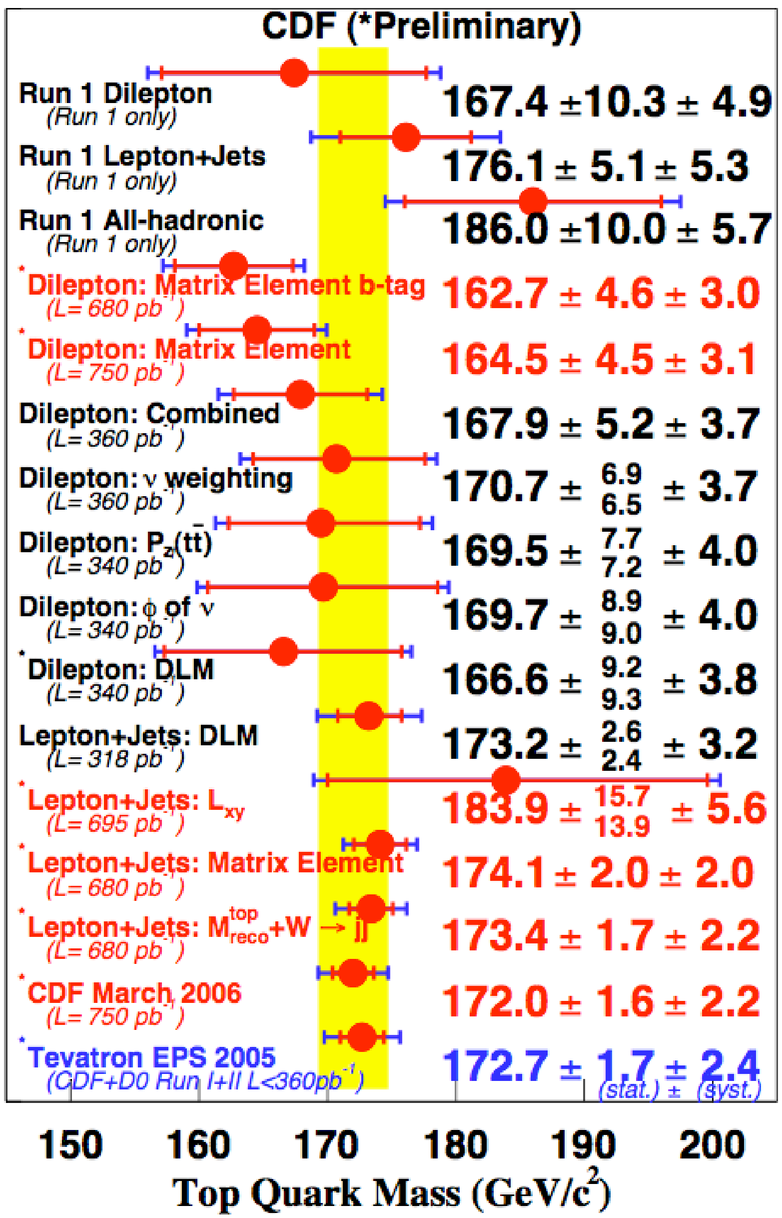
Source	*ΔM_{top}(GeV/c²)*
Remaining Jet Energy Scale	0.7
ISR/FSR	0.6
B-jet modeling	0.6
Background Shape	0.5
Background JES	0.4
Parton Distributions	0.3
Generator	0.2
Simulation Statistics	0.3
B-tagging	0.1
Total	**1.3**

Will improve:
Statistic DY & new approach

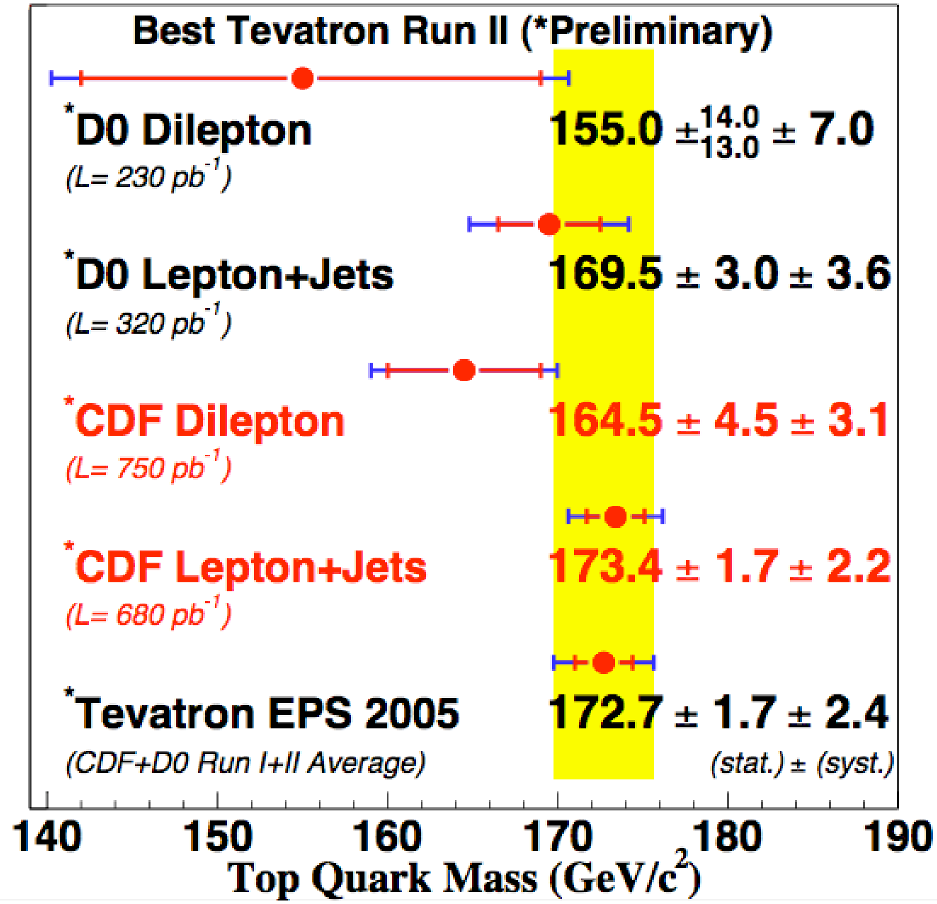
Will improve with statistic:
Z->bb data driven calibration

Will improve:
Statistic of w+jet & MC tools

Top mass

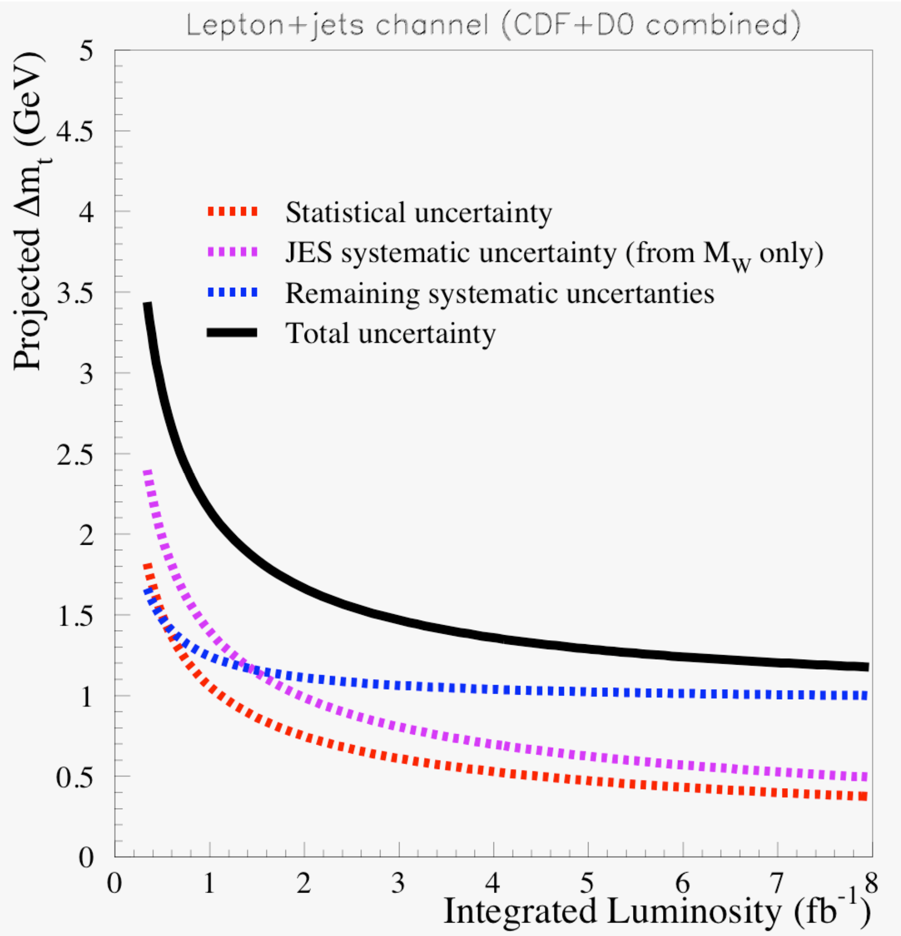


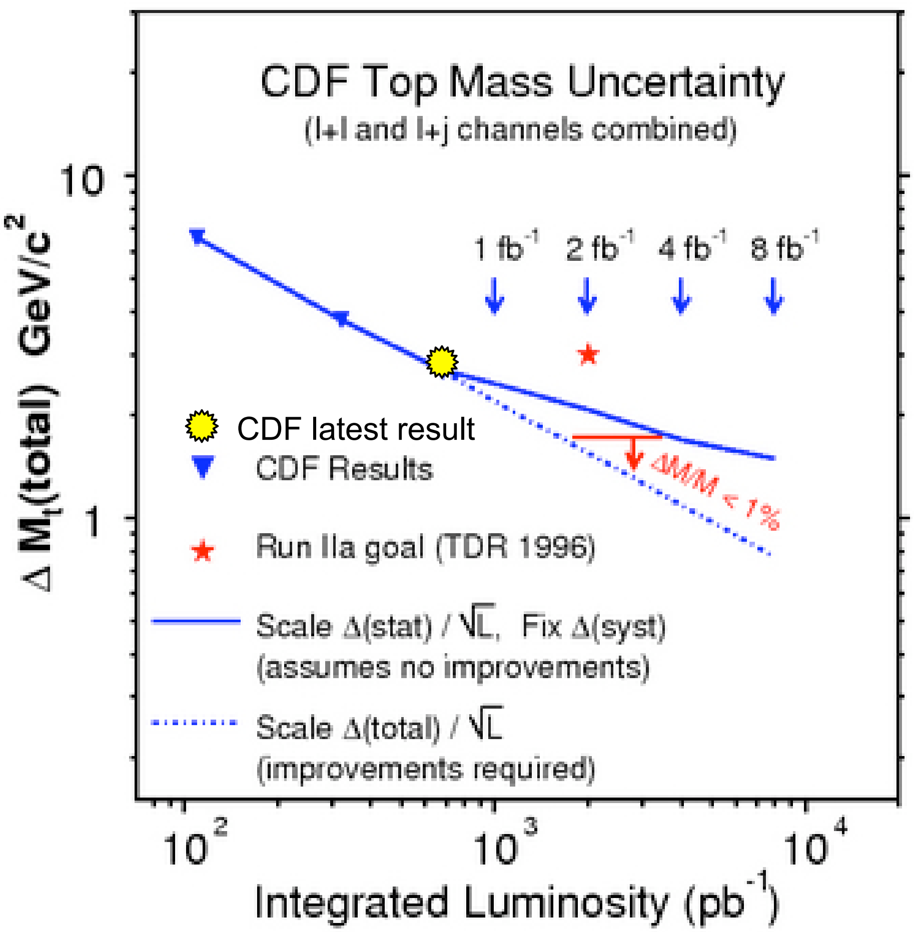
CDF (*Preliminary)
Run 1 Dilepton
(Run 1 only)
167.4 ±10.3 ± 4.9
Run 1 Lepton+Jets
(Run 1 only)
176.1 ± 5.1 ± 5.3
Run 1 All-hadronic
(Run 1 only)
186.0 ±10.0 ± 5.7
*Dilepton: Matrix Element b-tag
(L= 680 pb⁻¹)
162.7 ± 4.6 ± 3.0
*Dilepton: Matrix Element
(L= 750 pb⁻¹)
164.5 ± 4.5 ± 3.1
Dilepton: Combined
(L= 360 pb⁻¹)
167.9 ± 5.2 ± 3.7
Dilepton: ν weighting
(L= 360 pb⁻¹)
170.7 ± 6.9 6.5 ± 3.7
Dilepton: Pz(tt̄)
(L= 340 pb⁻¹)
169.5 ± 7.7 7.2 ± 4.0
Dilepton: φ of ν
(L= 340 pb⁻¹)
169.7 ± 8.9 9.0 ± 4.0
*Dilepton: DLM
(L= 340 pb⁻¹)
166.6 ± 9.2 9.3 ± 3.8
Lepton+Jets: DLM
(L= 318 pb⁻¹)
173.2 ± 2.6 2.4 ± 3.2
*Lepton+Jets: Lxy
(L= 695 pb⁻¹)
183.9 ± 15.7 13.9 ± 5.6
*Lepton+Jets: Matrix Element
(L= 680 pb⁻¹)
174.1 ± 2.0 ± 2.0
*Lepton+Jets: M top reco +W → jj
(L= 680 pb⁻¹)
173.4 ± 1.7 ± 2.2
*CDF March 2006
(L= 750 pb⁻¹)
172.0 ± 1.6 ± 2.2
*Tevatron EPS 2005
(CDF+D0 Run I+II L<360pb⁻¹)
172.7 ± 1.7 ± 2.4
(stat.) ± (syst.)
150
160
170
180
190
200
Top Quark Mass (GeV/c²)



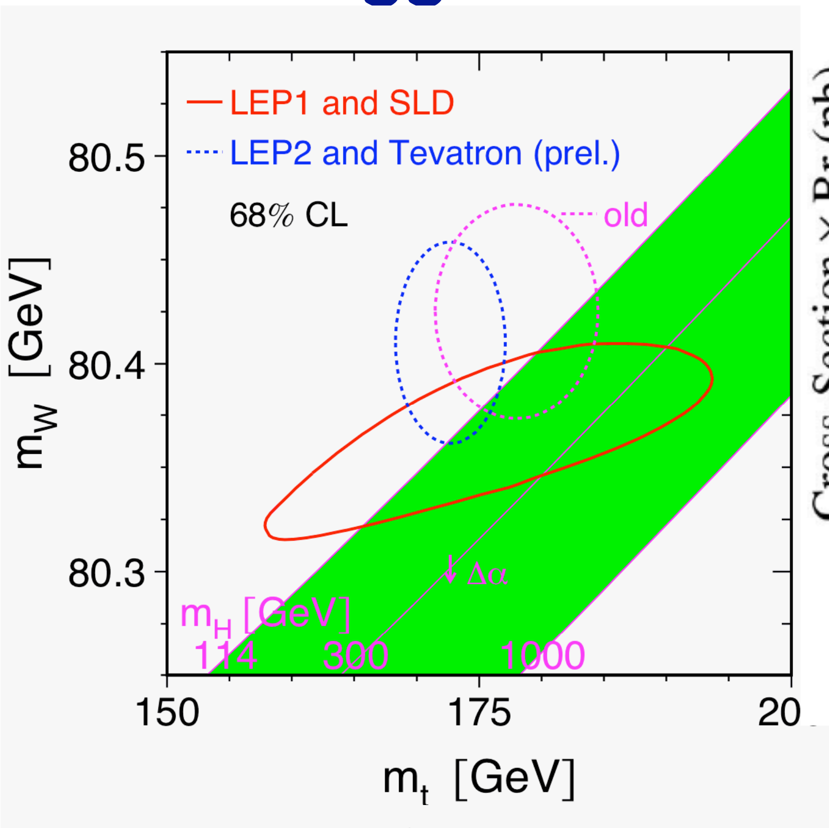
Best Tevatron Run II (*Preliminary)
*D0 Dilepton
(L= 230 pb⁻¹)
155.0 ± 14.0 13.0 ± 7.0
*D0 Lepton+Jets
(L= 320 pb⁻¹)
169.5 ± 3.0 ± 3.6
*CDF Dilepton
(L= 750 pb⁻¹)
164.5 ± 4.5 ± 3.1
*CDF Lepton+Jets
(L= 680 pb⁻¹)
173.4 ± 1.7 ± 2.2
*Tevatron EPS 2005
(CDF+D0 Run I+II Average)
172.7 ± 1.7 ± 2.4
(stat.) ± (syst.)
140
150
160
170
180
190
Top Quark Mass (GeV/c²)

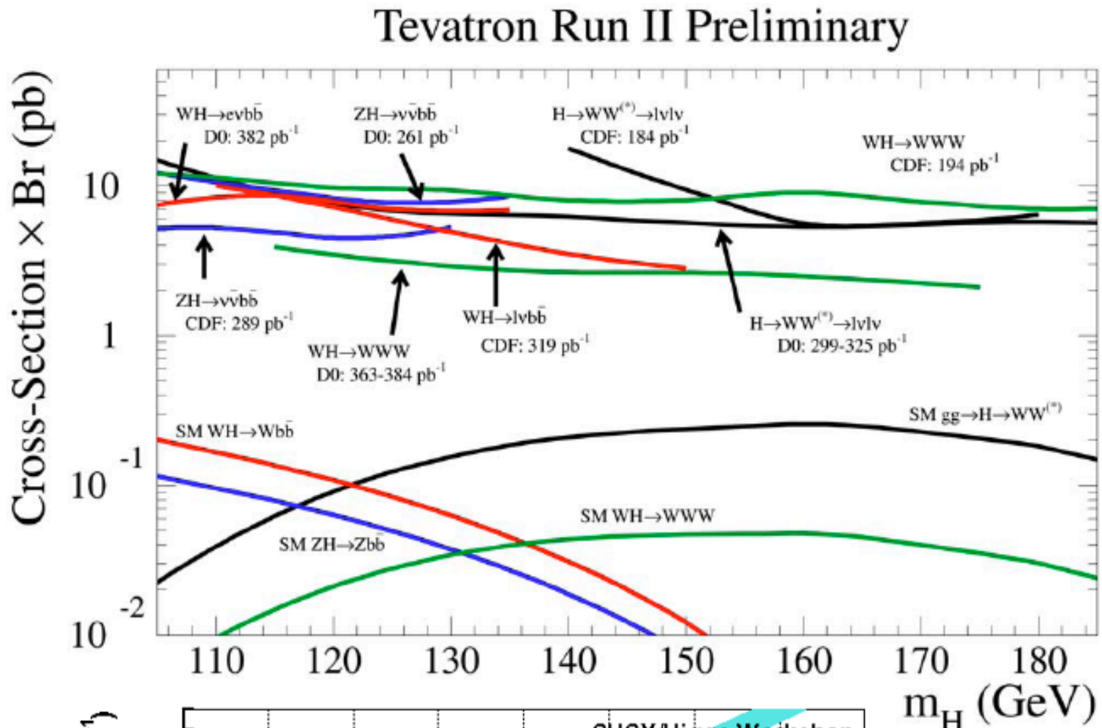
Projection for the M_{top} uncertainty

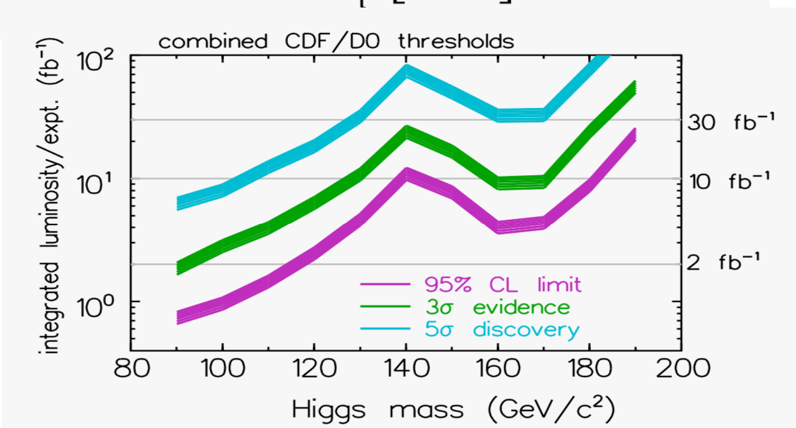


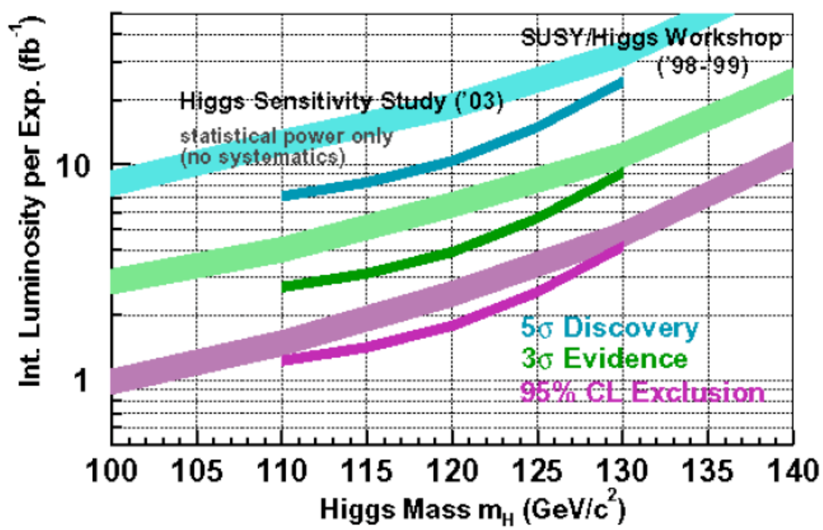


The Higgs boson searches







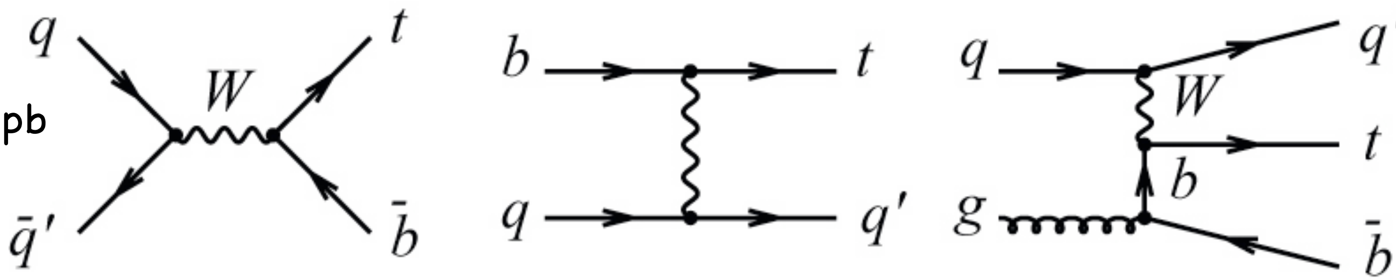


…but this is the subject of a different seminar

How else top quark is produced

Standard Model Tevatron Single Top Production

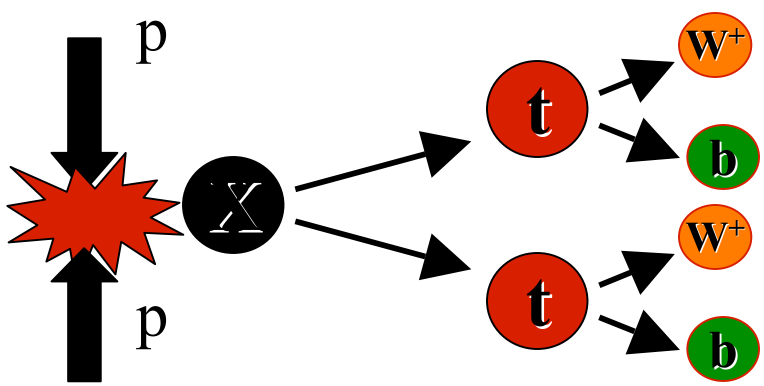
≈0.9 pb



≈2 pb

$$\sigma(\bar{p}p \to t + X @ M_{top} = 175 GeV) \approx 3 \text{ pb}$$

Direct measurement of V_{tb}



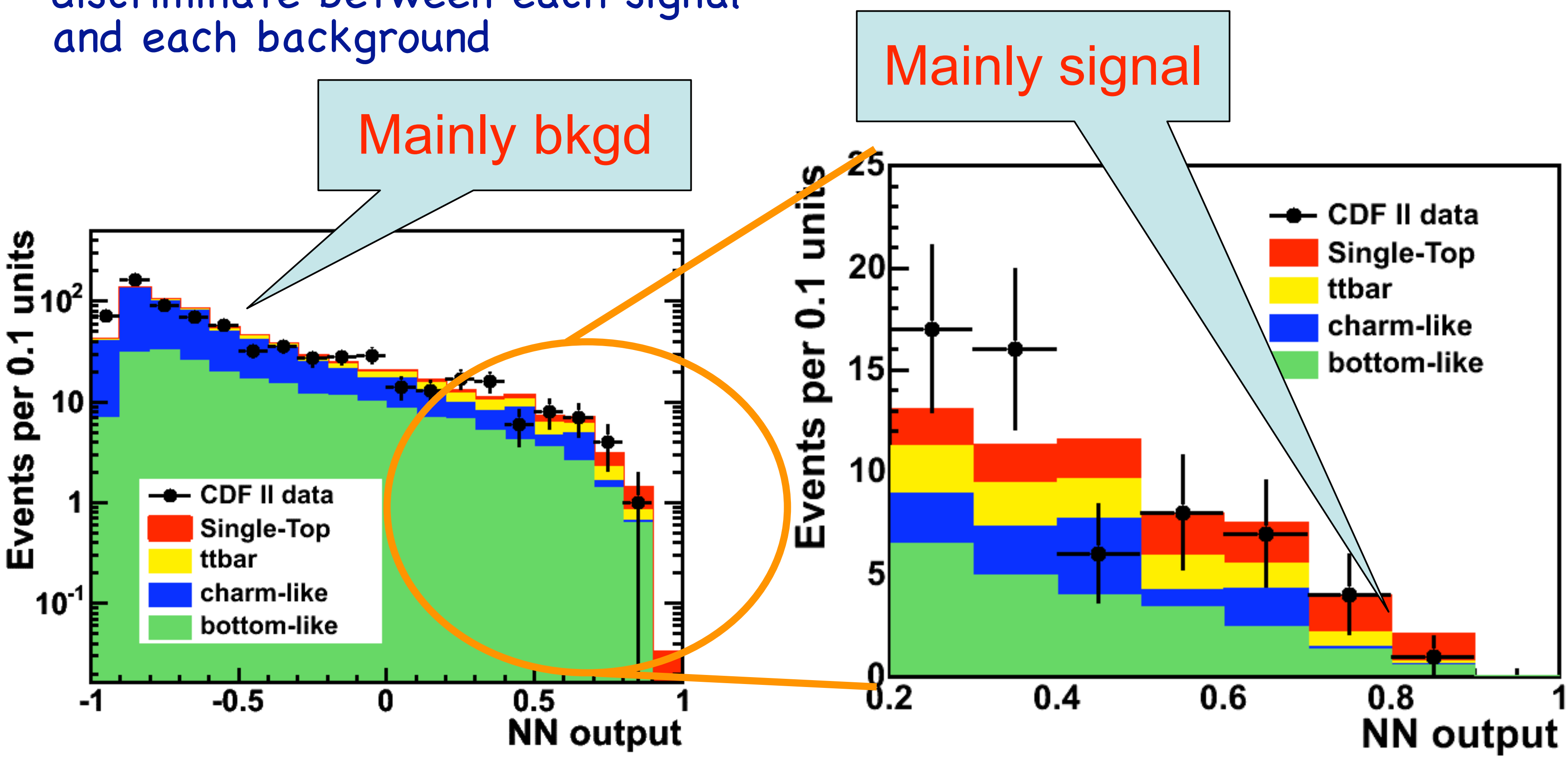
Resonance Production?

OR

?????

Search for single top quark production

- ✓ Why is it difficult?
  - Signal sandwiched between W+jets and top pair production
- ✓ Dedicated likelihood to discriminate between each signal and each background
- ✓ Neural network analysis to optimize sensitivity to signal against background

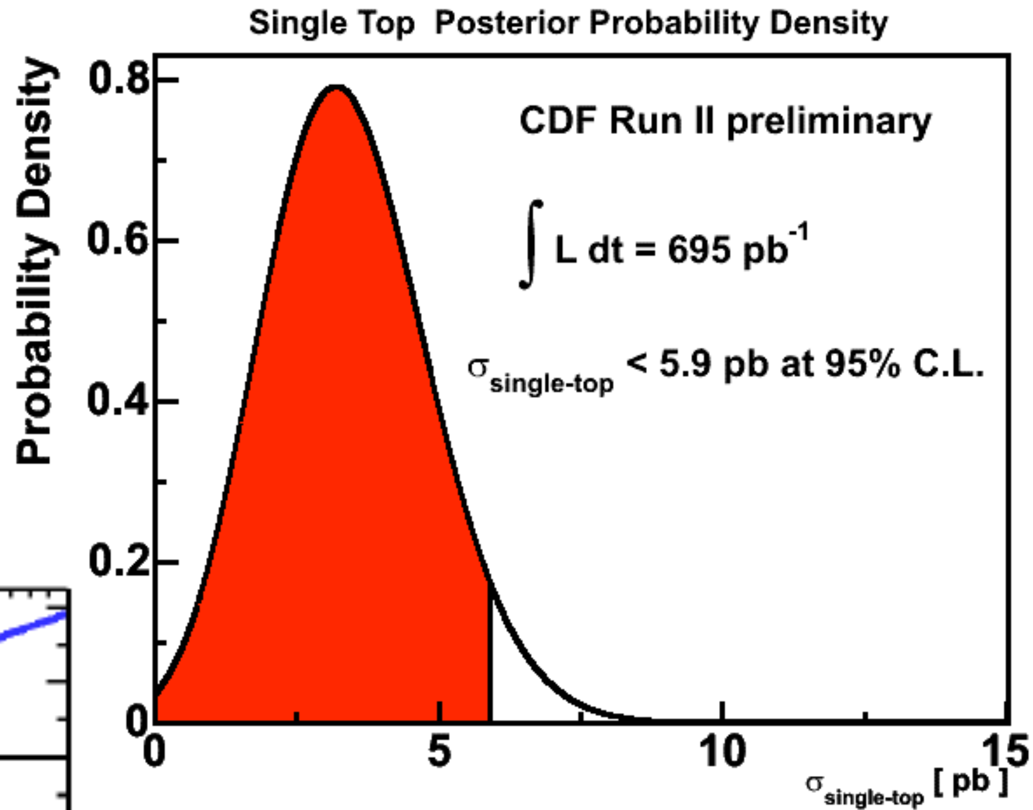


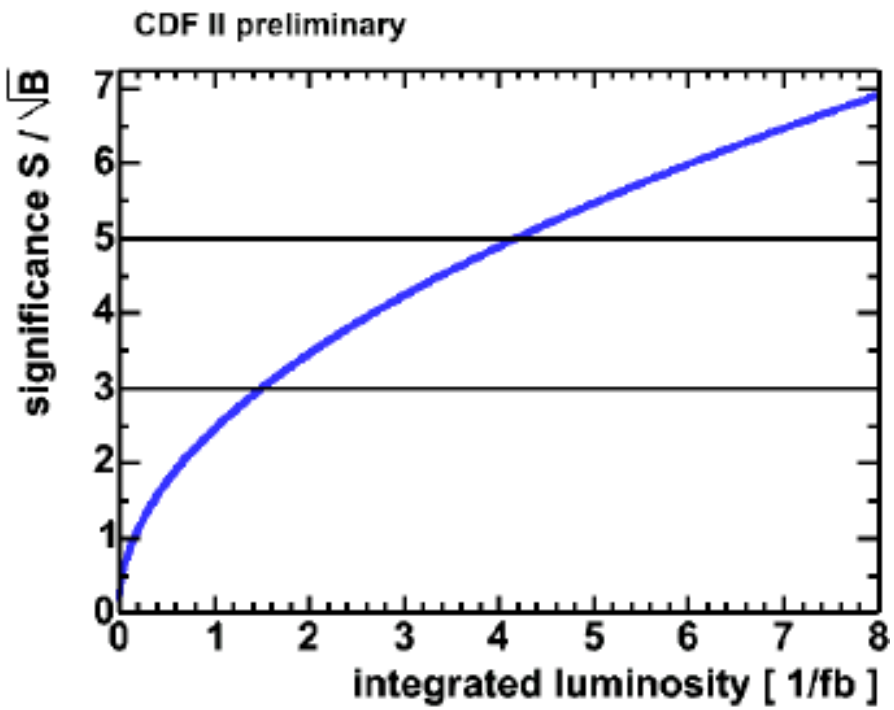
Search for Single Top Quark Production

Best fit value

$$\sigma(fit) = 3.2^{+1.5}_{-1.4}(stat)^{+2.4}_{-1.5}(syst)$$

SM Prediction ≈3pb

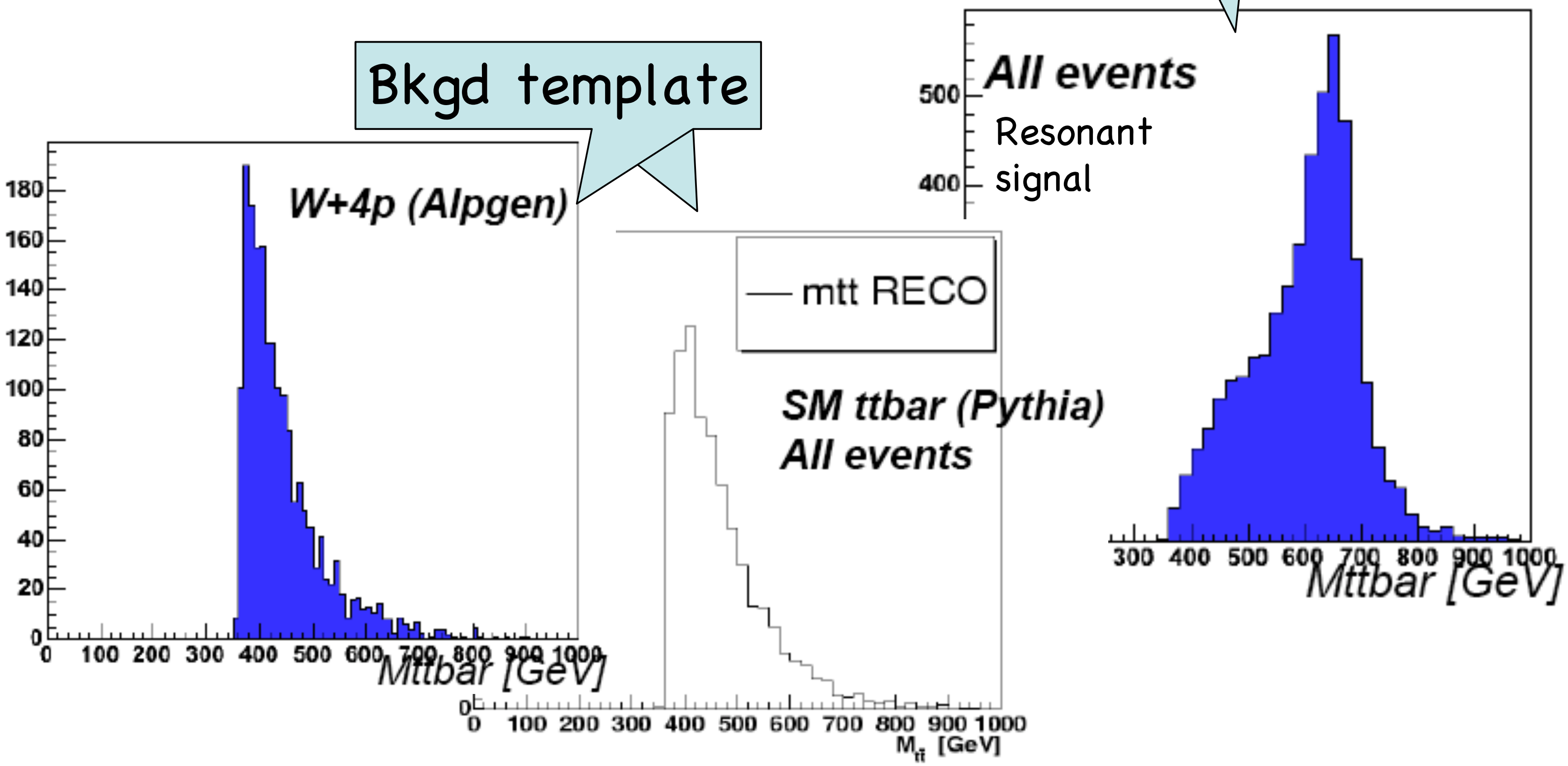




Top-antitop resonant production

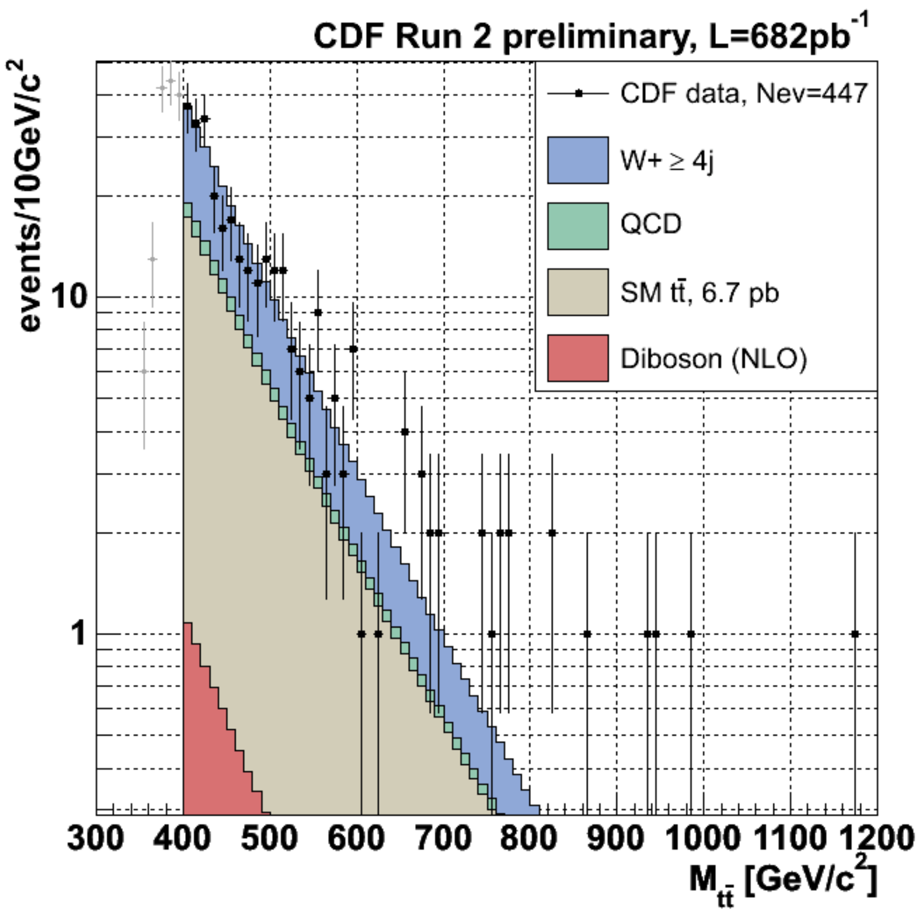
- ✓ Various exotic models predict the existence of heavy particles decaying to ttbar: Z-like vector
  - ✓ Lepton+≥4 jets (no b-tagging)
    - Matrix element technique to increase sensitivity

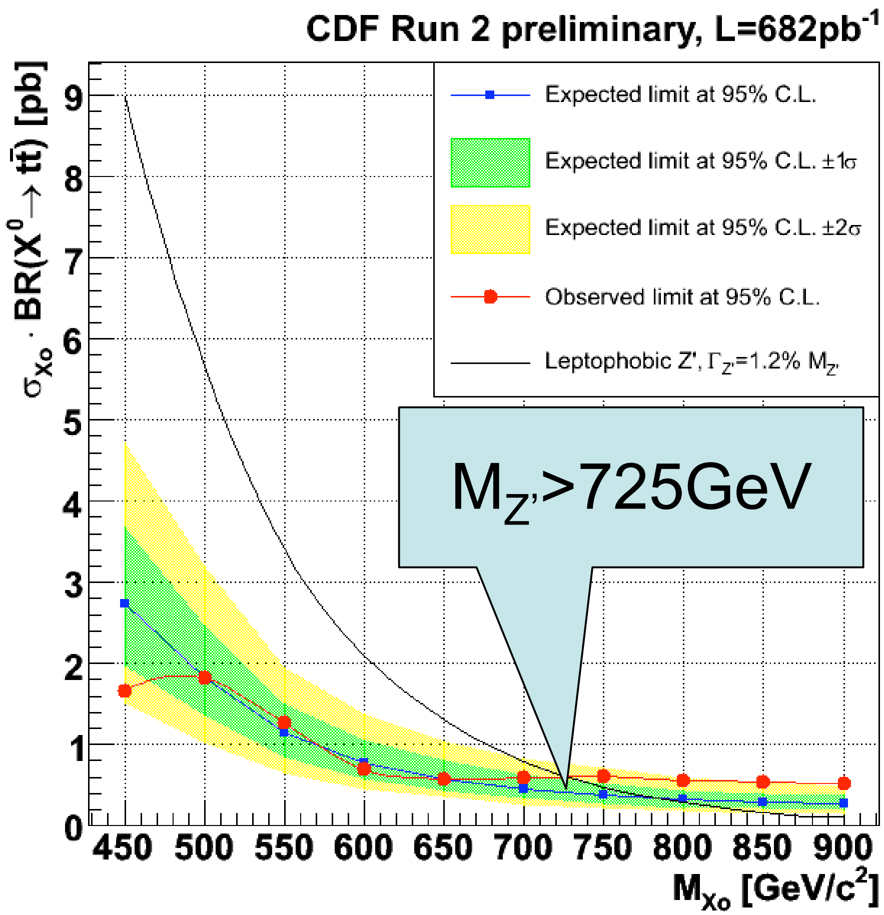
resonant template



What does CDF observe in the tt mass?

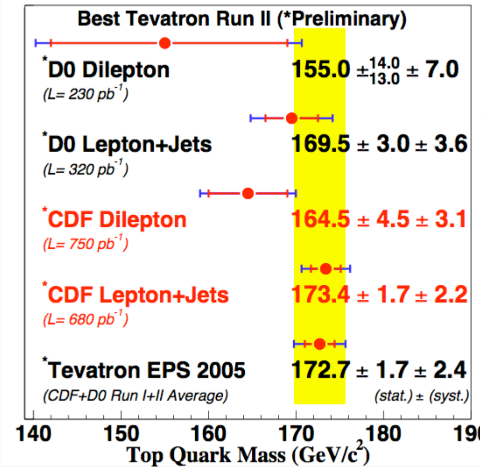
- ✓Fix top pair, diboson, QCD to expected rates
  - ➧Assume everything else is W+jets

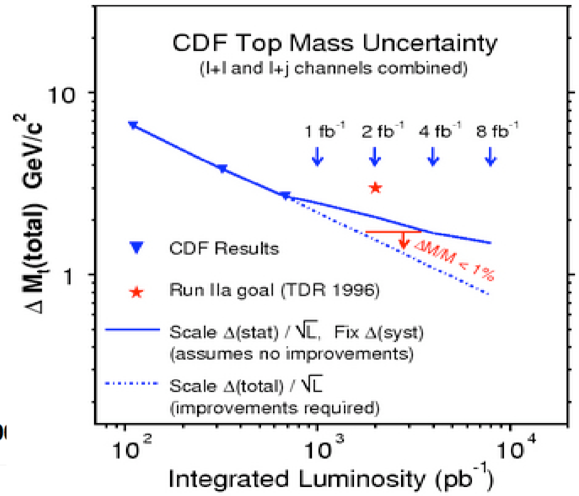




Summary

Tevatron delivered More than 1.6 fb^{-1}; 4fb^{-1} by 2009





σ_{top}=7.3±0.5±0.6±0.4 pb

M_{top}=172.7±1.7±2.4 GeV/c^2

CDF II world best measurement

ΔM_{top}< 2 GeV/c^2 with 2fb^{-1}

- Our syst. due to JES and bkgd shape are expected to be improved soon
- B-tagging will be soon better performing

- Single top production σ<5.9 pb - expected first hint of signal with 2fb^{-1}
- no evidence of resonance M_{tt}<750GeV

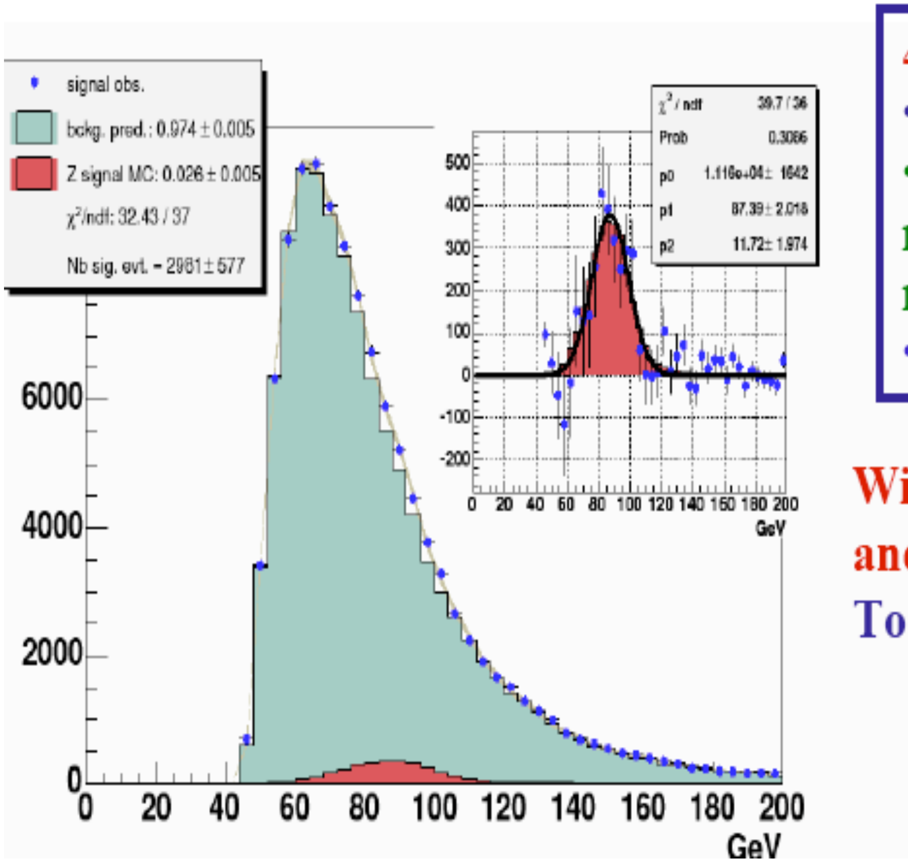
- We have few hundreds of top event and we will double the statistic soon, we are ready to have an impact on characterizing top properties

Backup slides & additional material

Other Top Properties Measurements

Measurement	Result	$\int L dt$ (pb^{-1})
W helicity F_0	$0.74^{+0.22}_{-0.34}$	200
W helicity F_+	$F_+ < 0.27$ @ 95% CL	200
Search for anomalous kinematics	Consistent with SM	193
Search for H^+ in t decays	BR($t \to Hb$) $<$ 0.91 @ 95% CL	193
$\sigma_{dilepton}/\sigma_{l+jets}$	$1.45^{+0.83}_{-0.55}$ (stat + syst)	126
BR($t \to Wb$)/BR($t \to Wq$)	> 0.61 @ 95% CL	162
BR($t \to \tau\nu_\tau q$)/BR$_{SM}$($t \to \tau\nu_\tau q$)	< 5.2 @ 95% CL	193
Search for 4th generation t' quark	$m_{t'} < 196, m_{t'} > 207$ @ 95% CL	347
Top quark lifetime	$c\tau_{top} < 52.5\ \mu m$ @ 95% CL	350

B jet corrections: Z->bb



400 pb^{-1} (but most part taken with DPS...).

- Two tagged jets w/ E_t(L5)>22 GeV, $|\eta|<1.5$.
- Reduce QCD background and ISR/FSR by requesting back-to-back events with low extra jet radiation.
- Data driven background computation.

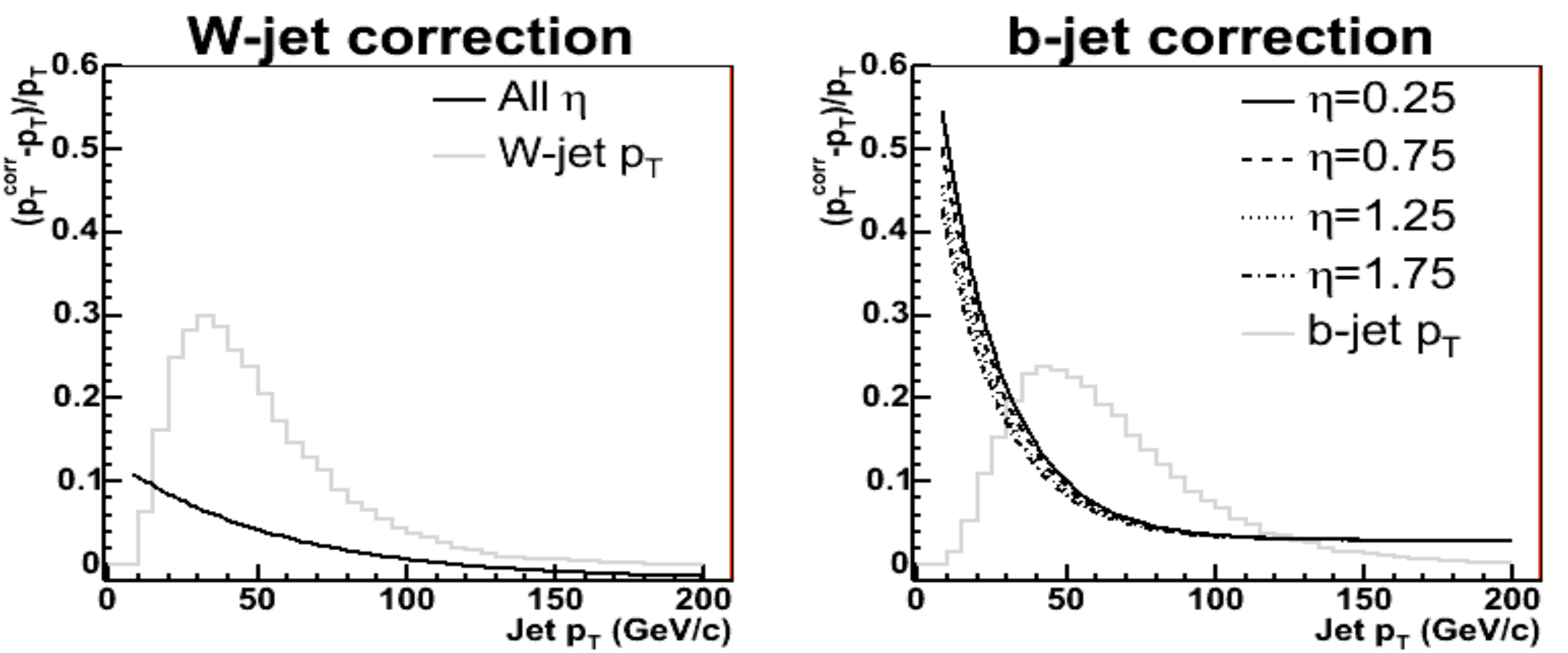
With new data: aim to extract a cleaner signal and perform a *first* b JES measurement.

To reach a measurement at the 2% level:

- 1 fb^{-1} of usable data
- develop tools that improve b-jet energy resolution (Hyperball, NN).

b-jets require specific corrections

Separate corrections are applied to b-quark jets and light-quark jets (from W), because of different response of b-parton and light parton.

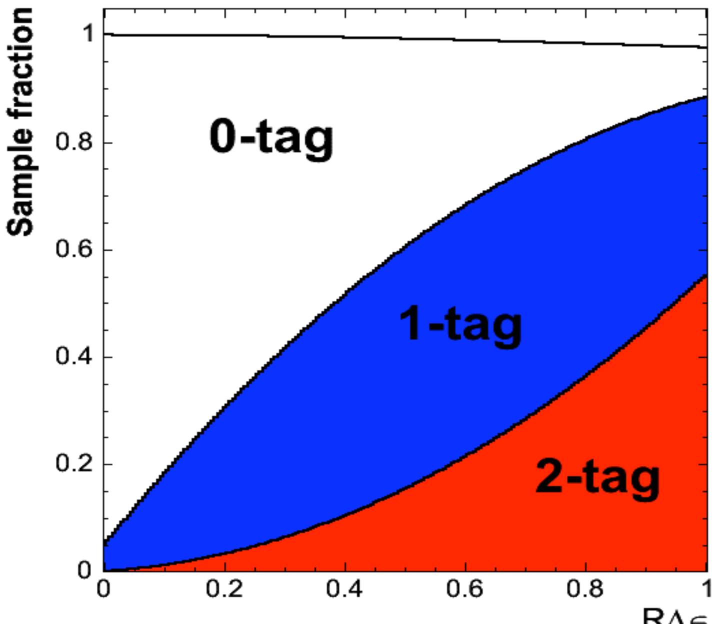


Does top always decay to b quark?

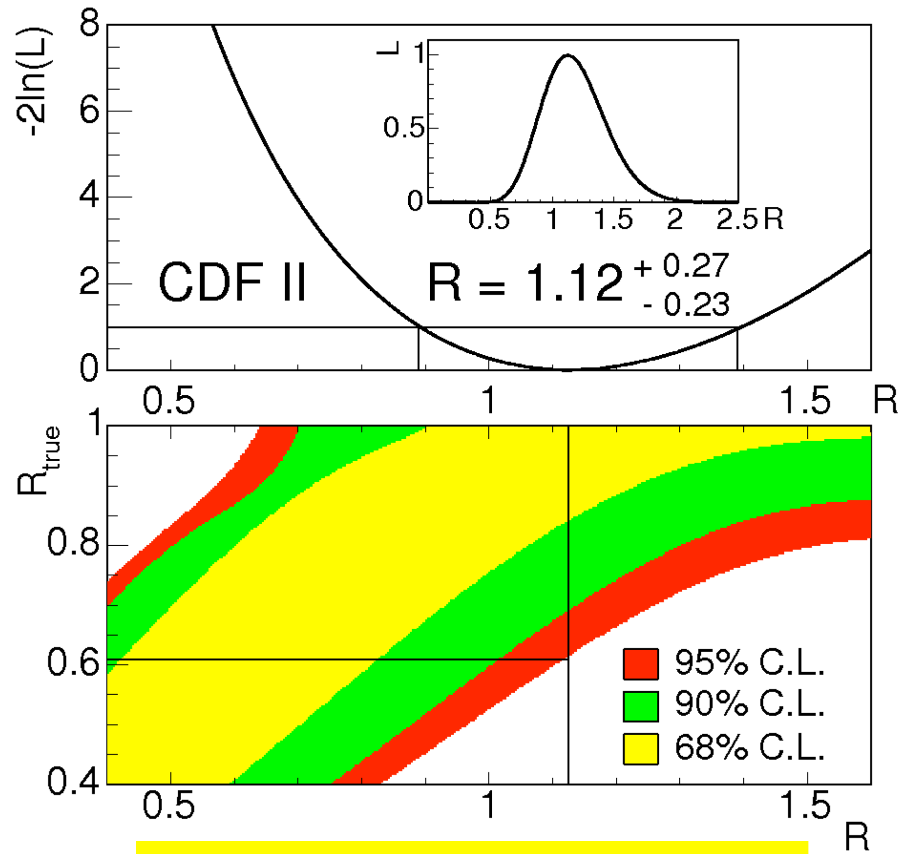
Fit R= R=BR(t→Wb) / BR(t→Wq) times b-tag efficiency from observed number and estimated composition of 0,1,2-tag dilepton and lepton+jets events

$$N_{inc}^{t\bar{t}} = \sum_i (N_i^{obs} - N_i^b)$$

$$N_i^{exp} = N_{inc}^{t\bar{t}} \cdot \epsilon_i(R) + N_i^b$$



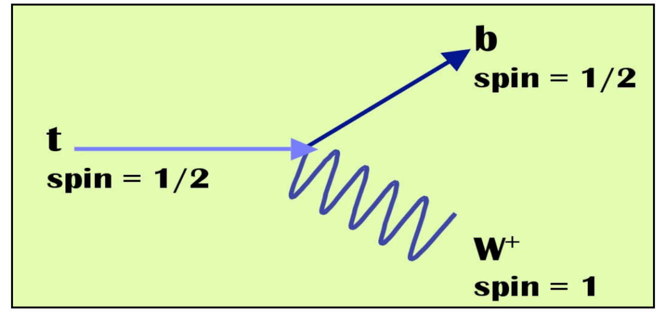
$\Delta\varepsilon = \varepsilon_b - \varepsilon_{light} = 0.44 \pm 0.03$
from independent estimate



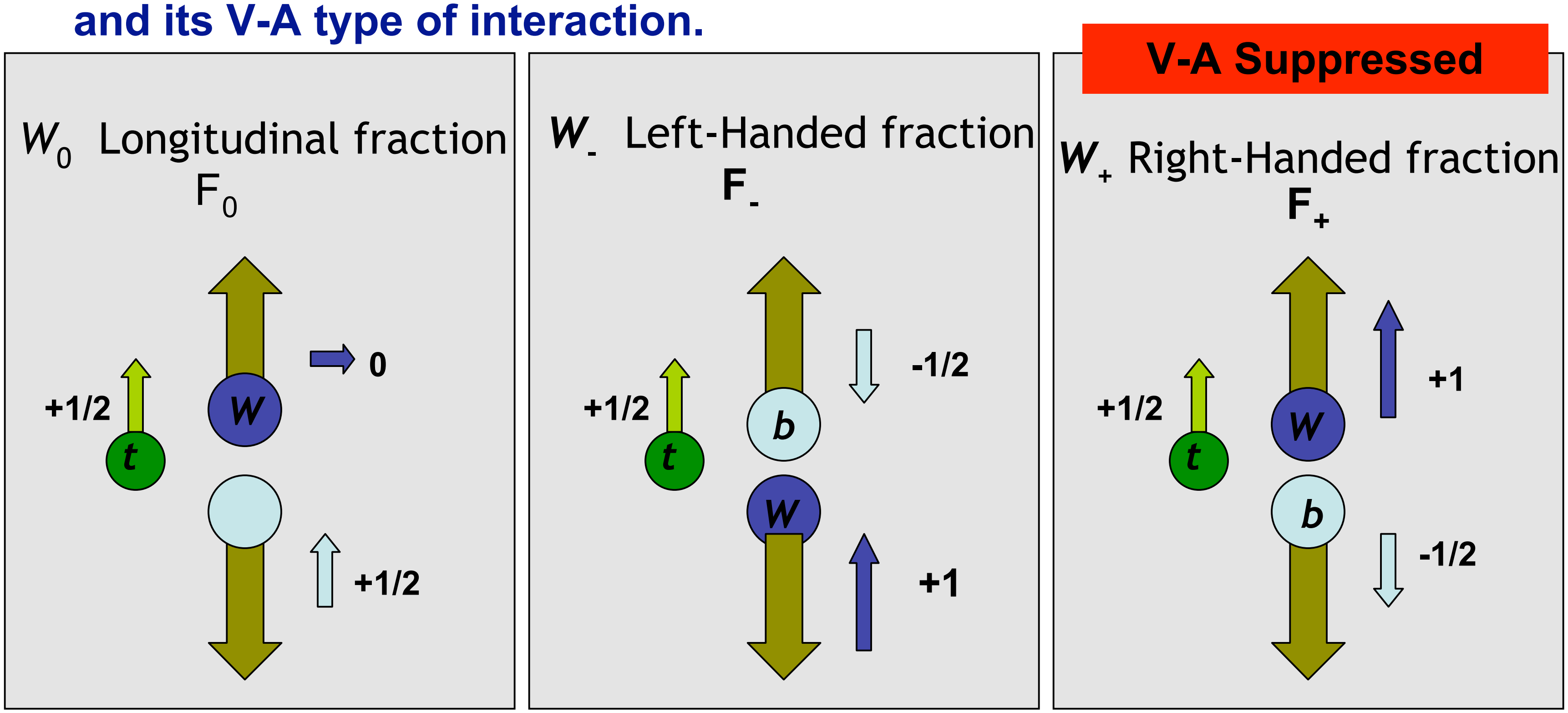
R>0.62 @ 95% C.L.

W helicity from t->Wb decays

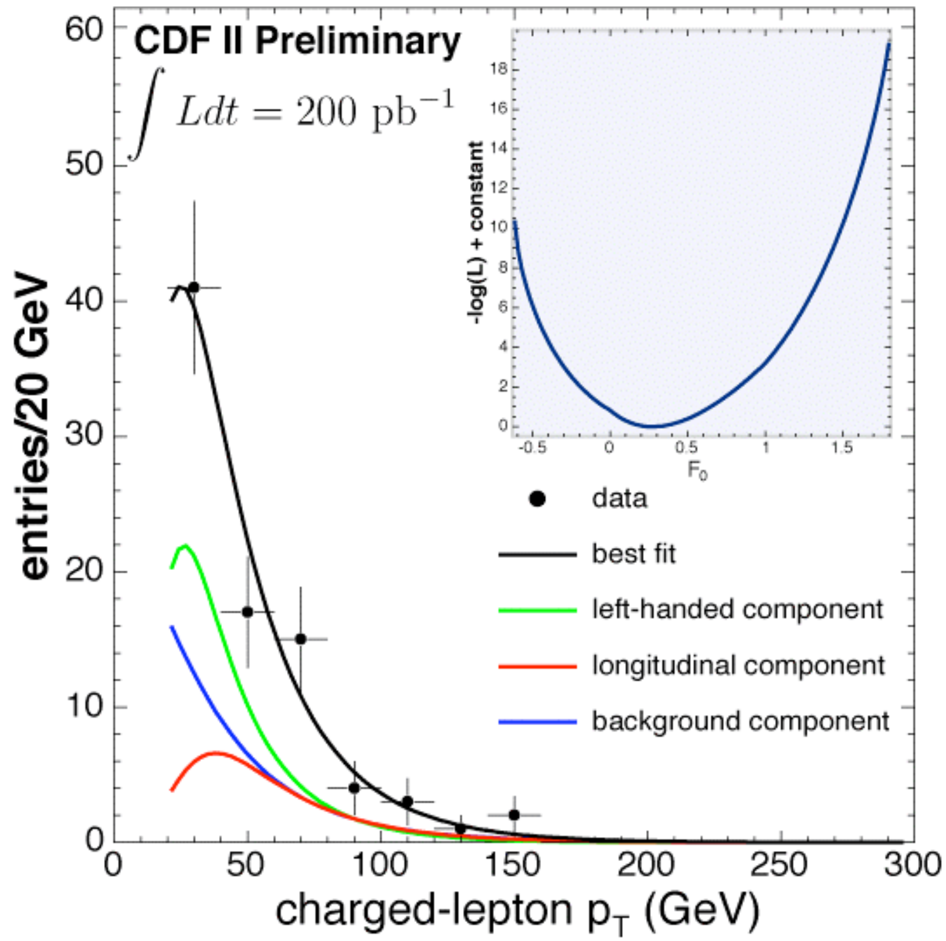
- ✓ **Examines the nature of the tWb vertex, probing the structure of weak interactions at energy scales near EWSB**



- ✓ **Stringent test of SM and its V-A type of interaction.**



Run II W helicity in top events



The combined dilepton and lepton+jets b-tagged events plotted against the best fit.

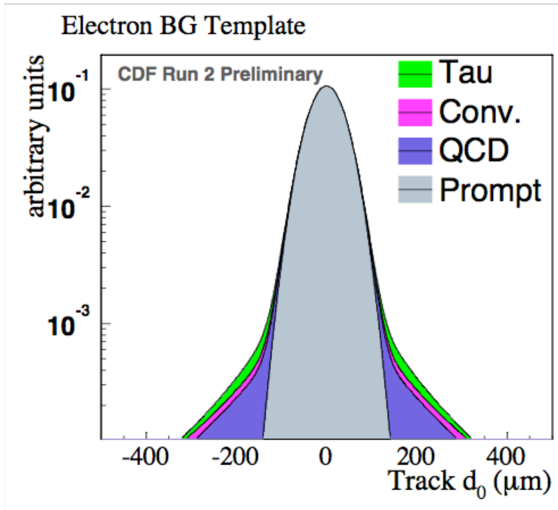
SM: Only longitudinal and left-handed W's can be produced in the top rest frame.

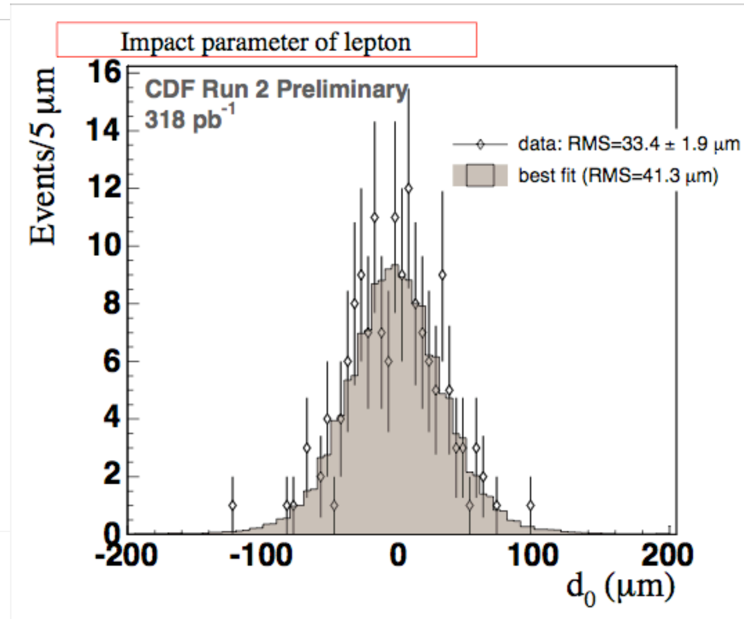
Use lepton p_T spectra to determine the fraction F_0 of longitudinally polarized W's.

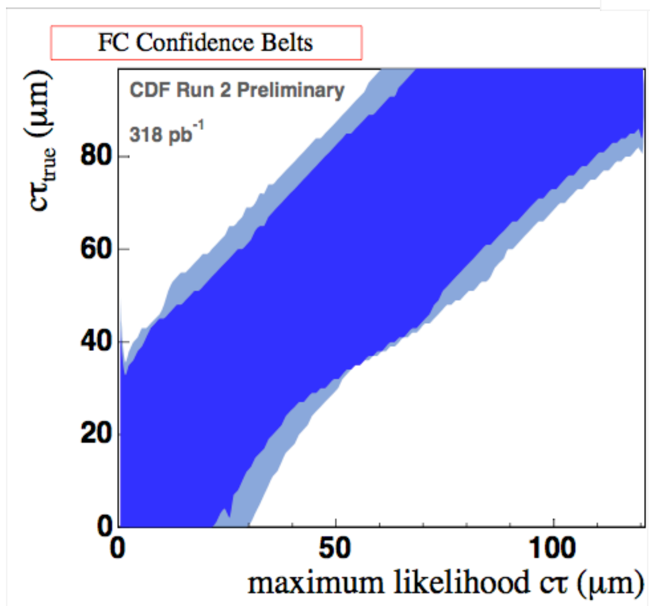
F_0 = 0.7 in the Standard Model

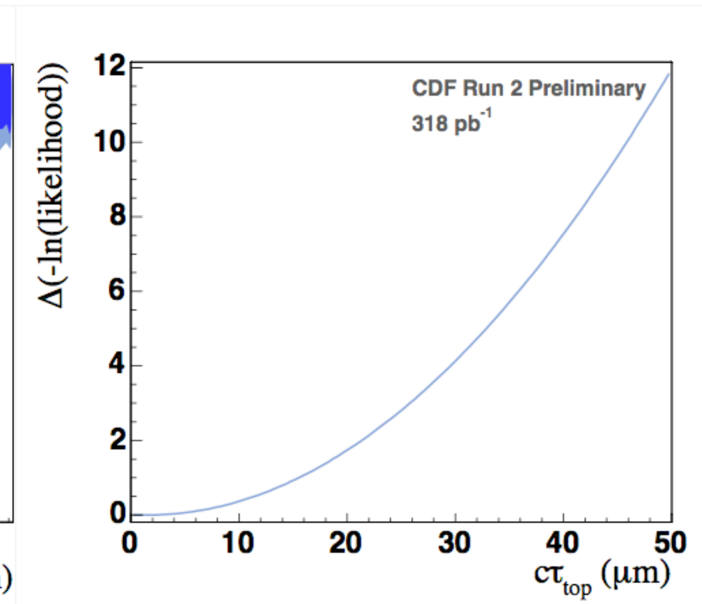
Result: $F_0 = 0.27 + 0.35 - 0.21$
Or $F_0 < 0.88$ @ 95% CL

Top lifetime



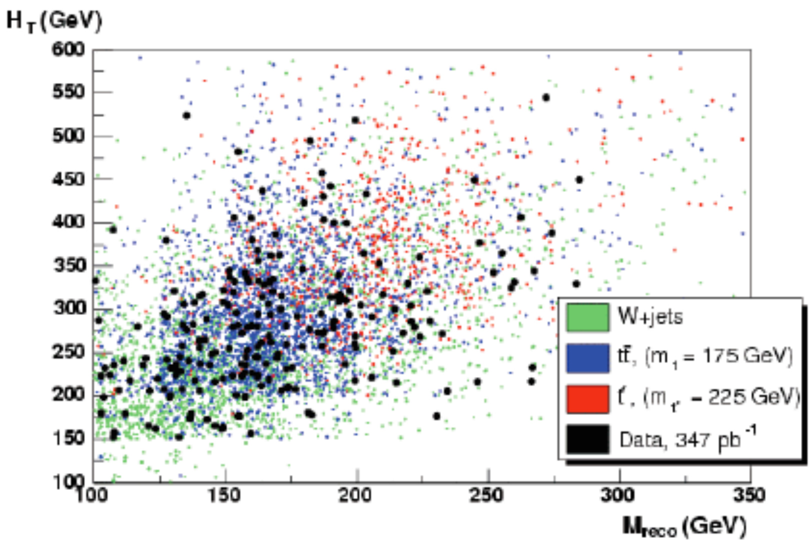


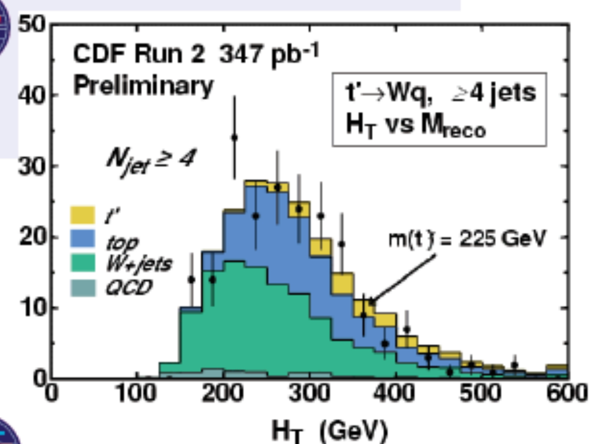


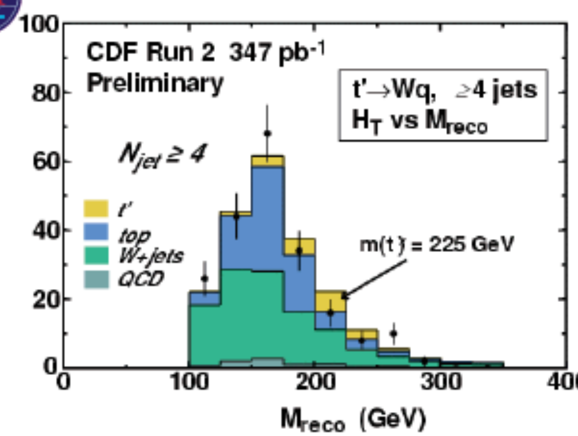


Can we find something heavier with top properties

Heavy quarks (4th generation) t' → Wq exist in various extensions of the SM.
- search for t' → Wq in lepton + jets + missing E_T events (CDF, 347pb^{-1})
- try to remain model independent
- reconstruct t' candidate mass
- fit templates in (H_T, $M_{t'}$)

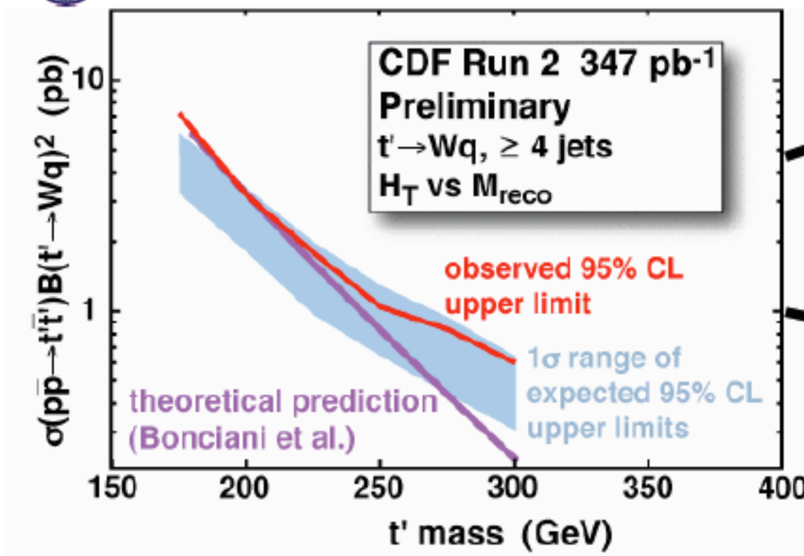


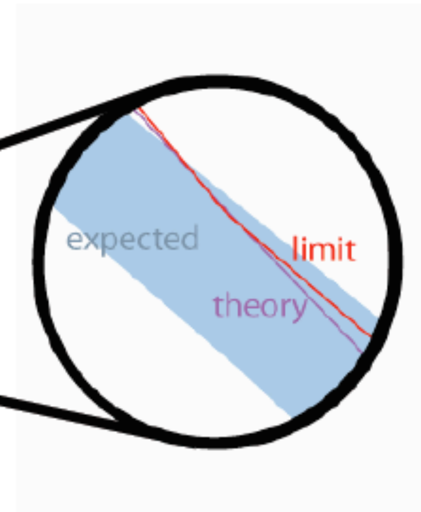




- no evidence for t' in 347pb^{-1}

t' cross section limit.





translate cross section limit into a t' prime mass limit of

196 – 207 GeV/c^2 @ 95 CL

for a true top mass of 175 GeV/c^2.

expect m(t') > 300 GeV/c^2 with 2fb^{-1} unless ...

B-tagging

SecVtx b-tagging:

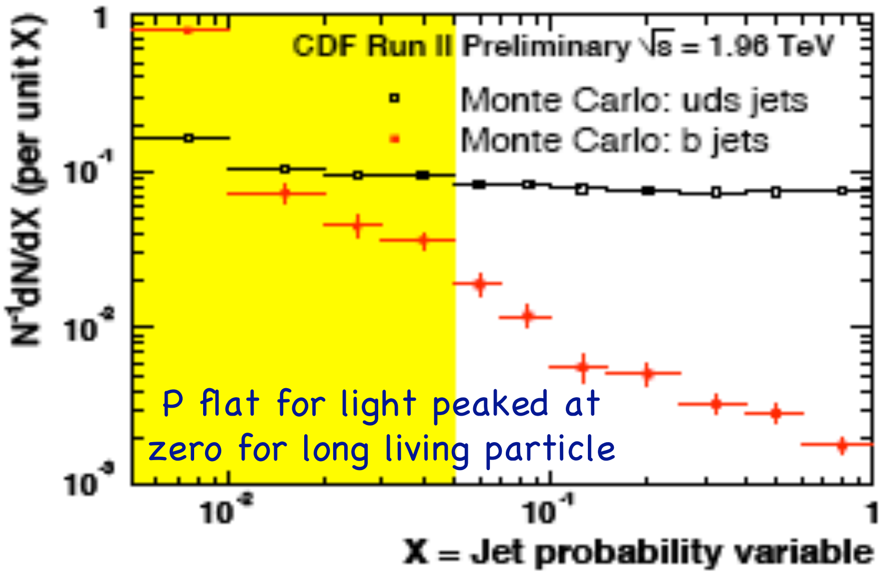
- ✓ Identify displaced vtx inside a jet

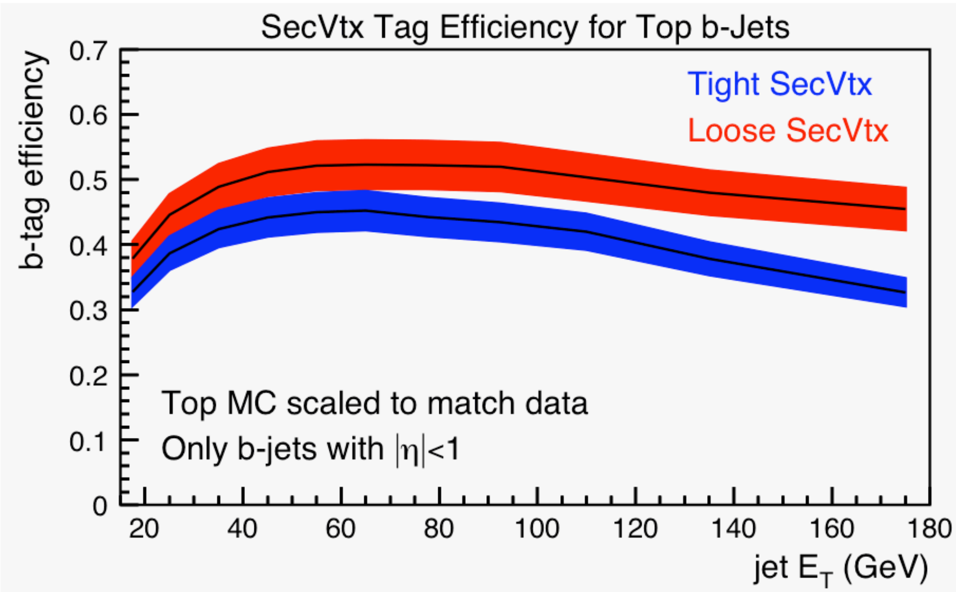
Jet probability b-tagging:

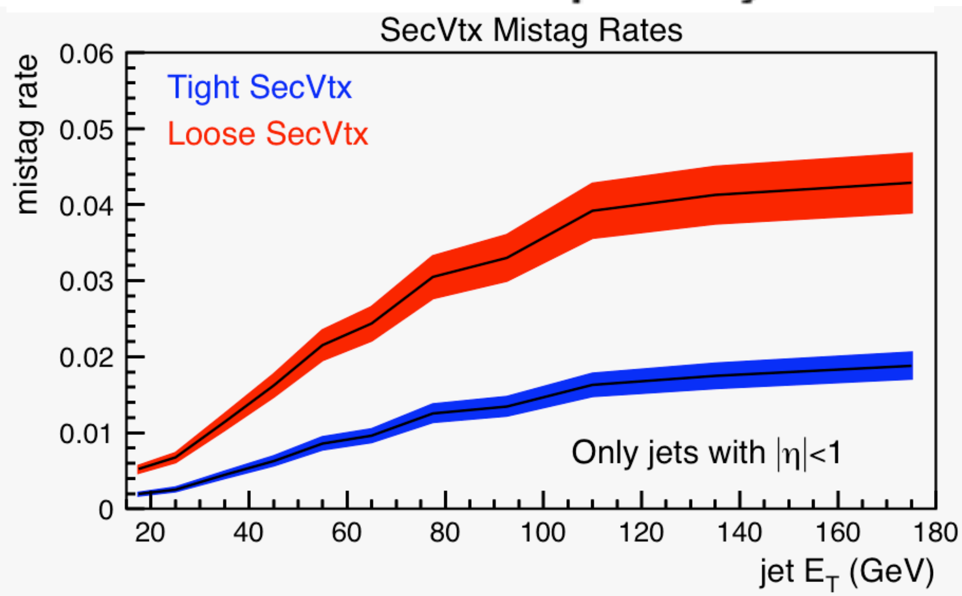
- ✓ Probability that jet tracks come from primary vertex

Soft lepton b-tagging:

- ✓ Identify leptons(eμ) from HF decay



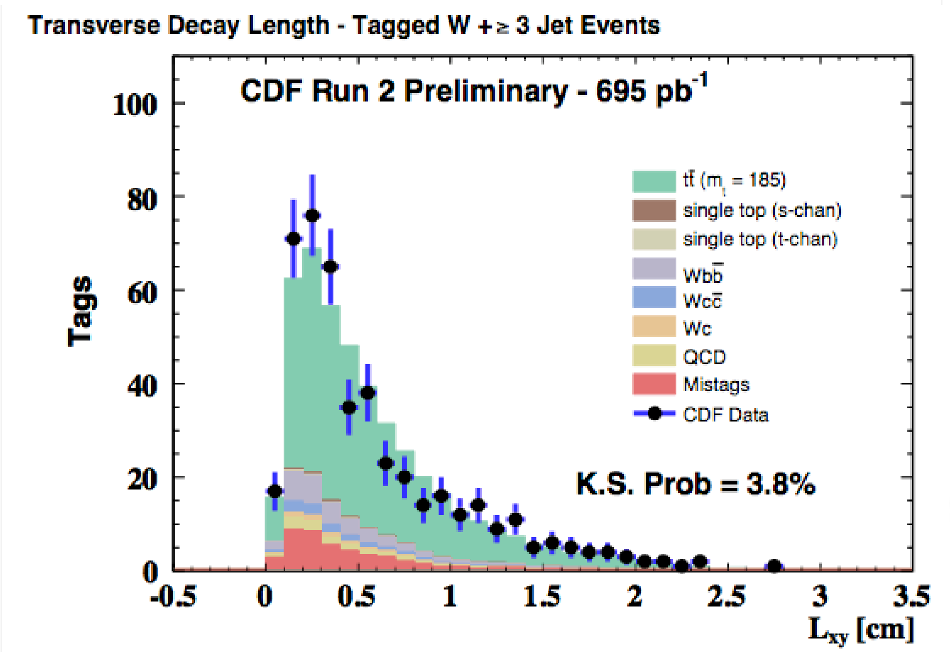


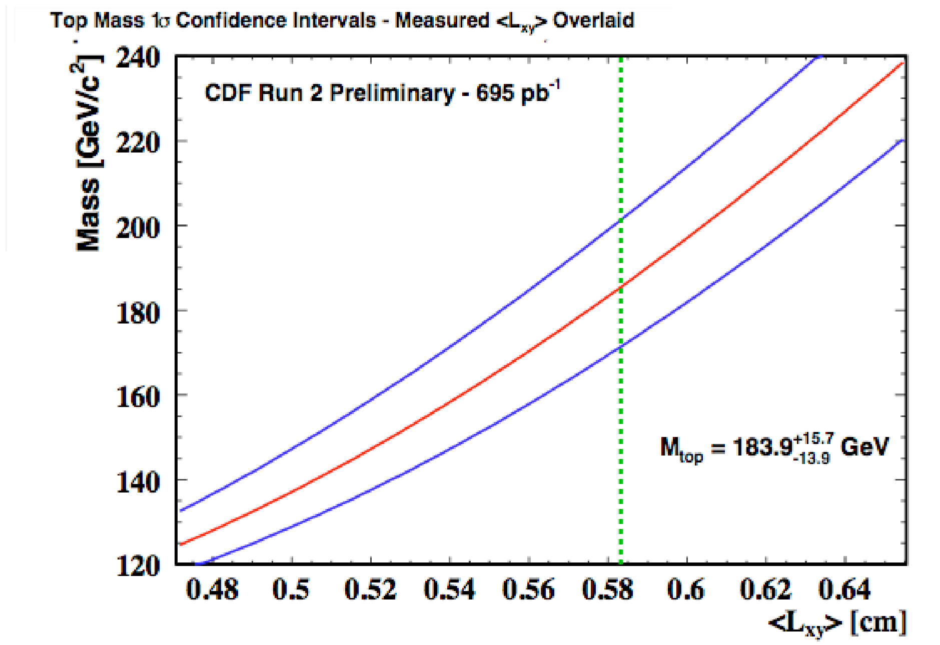


SecVtx is the algorithm used for the results presented here.

Top mass with the decay length technique

$$\gamma_b = \frac{m_t^2 + m_b^2 - m_W^2}{2 m_t m_b} \approx 0.4 \frac{m_t}{m_b}$$





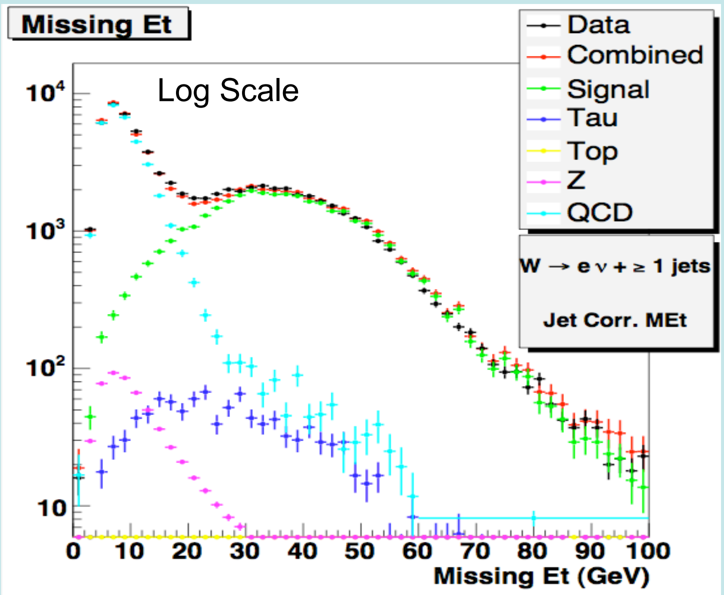
$$m_t = 183.9^{+15.7}_{-13.9}\ (stat.)\ \pm\ 5.6\ (syst.)\ GeV/c^2$$

Analysis outline

High P_T electron trigger 320pb^{-1} ⇒ Identify W event, reconstruct jets

Backgrounds:

- QCD from data: by reversing lepton-ID selection
- W-like from MC
- Promotion from Minimum Bias
- relative normalization from template fit to ME_T to data

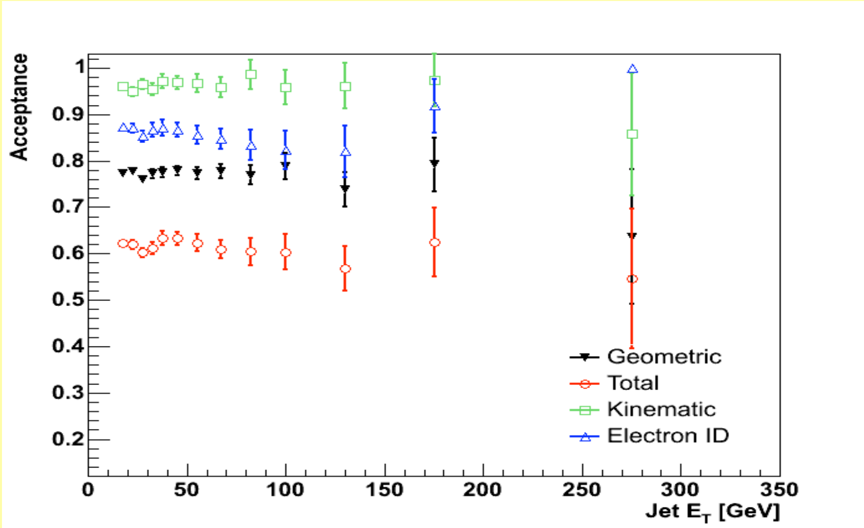


Acceptance:

✓ Defining σ wrt W detector acceptance:
  - correct only for detector resolution effects - independent of th model

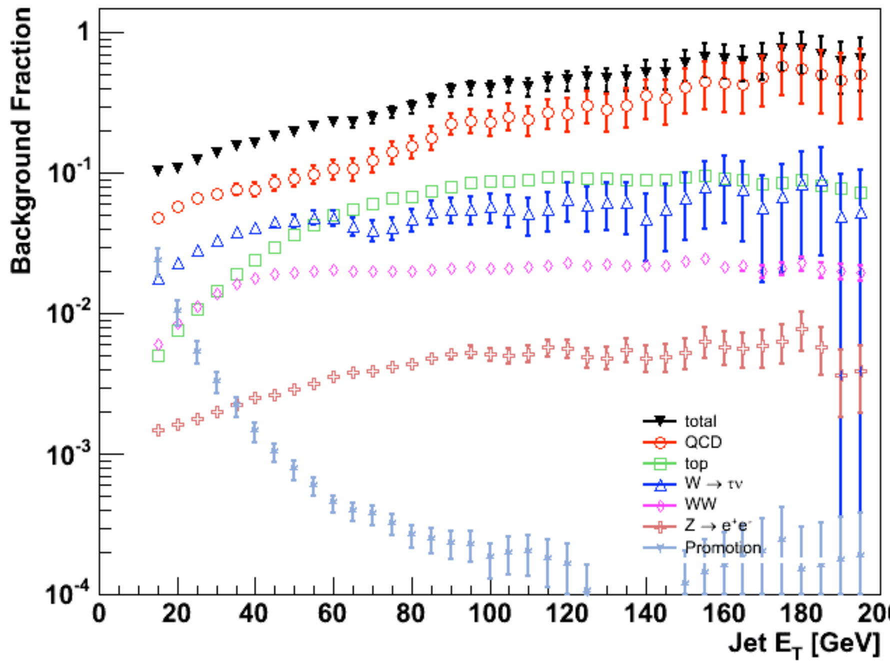
✓ Use W+np MC for acceptance & ID

✓ Validation: ID on Z data, acceptance by studying different MC.

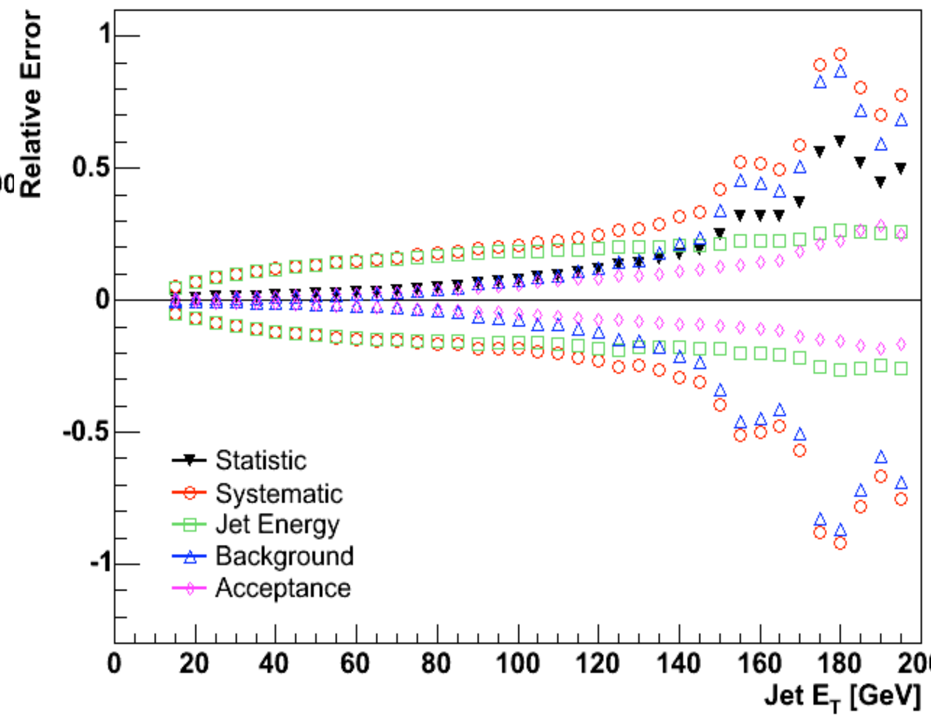


Background and systematic error picture

W+1j integated E_T spectrum

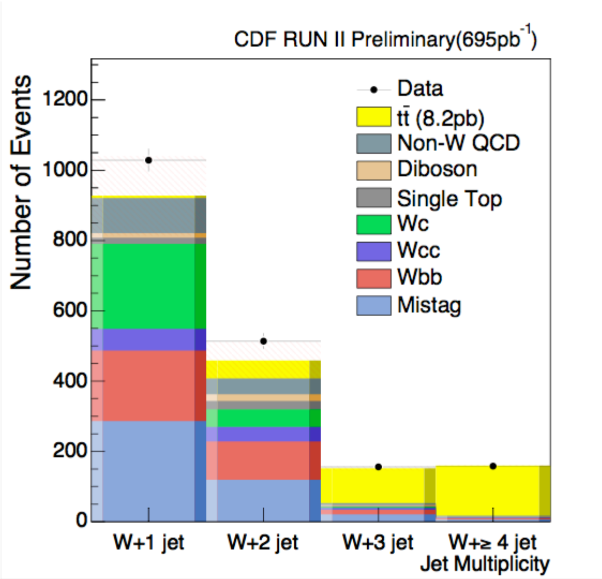


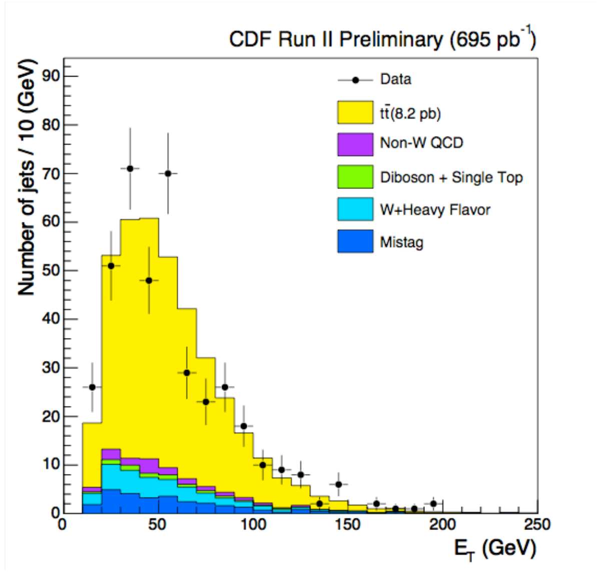
Tot
QCD
Top
W->tv
WW
Z->ee

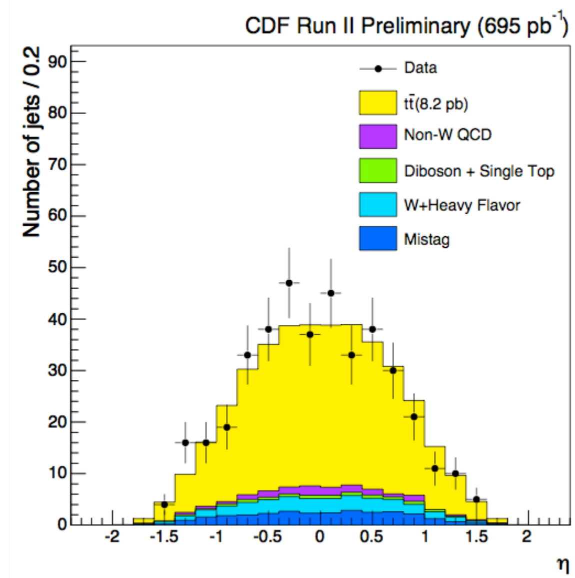


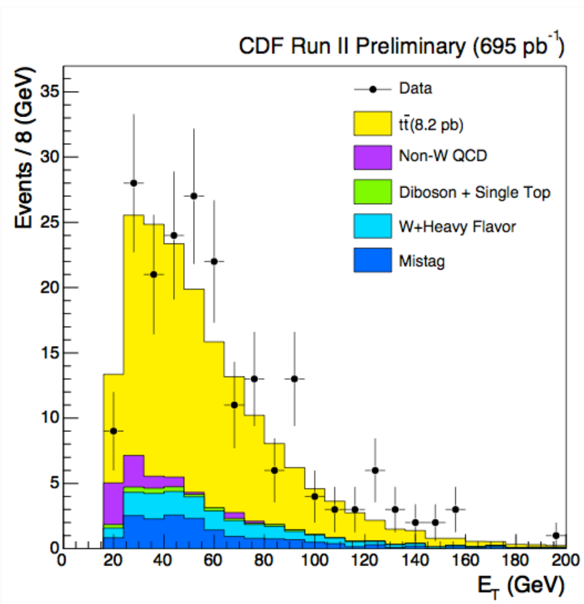
Stat
Tot
bkgd
JES

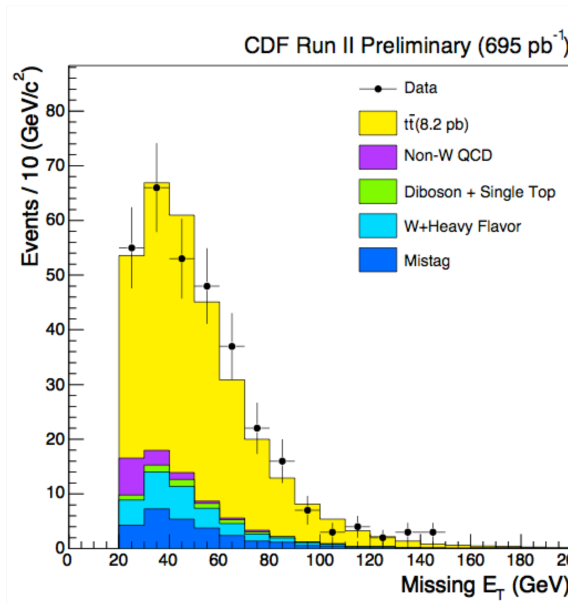
Kinematic data Monte Carlo comparison

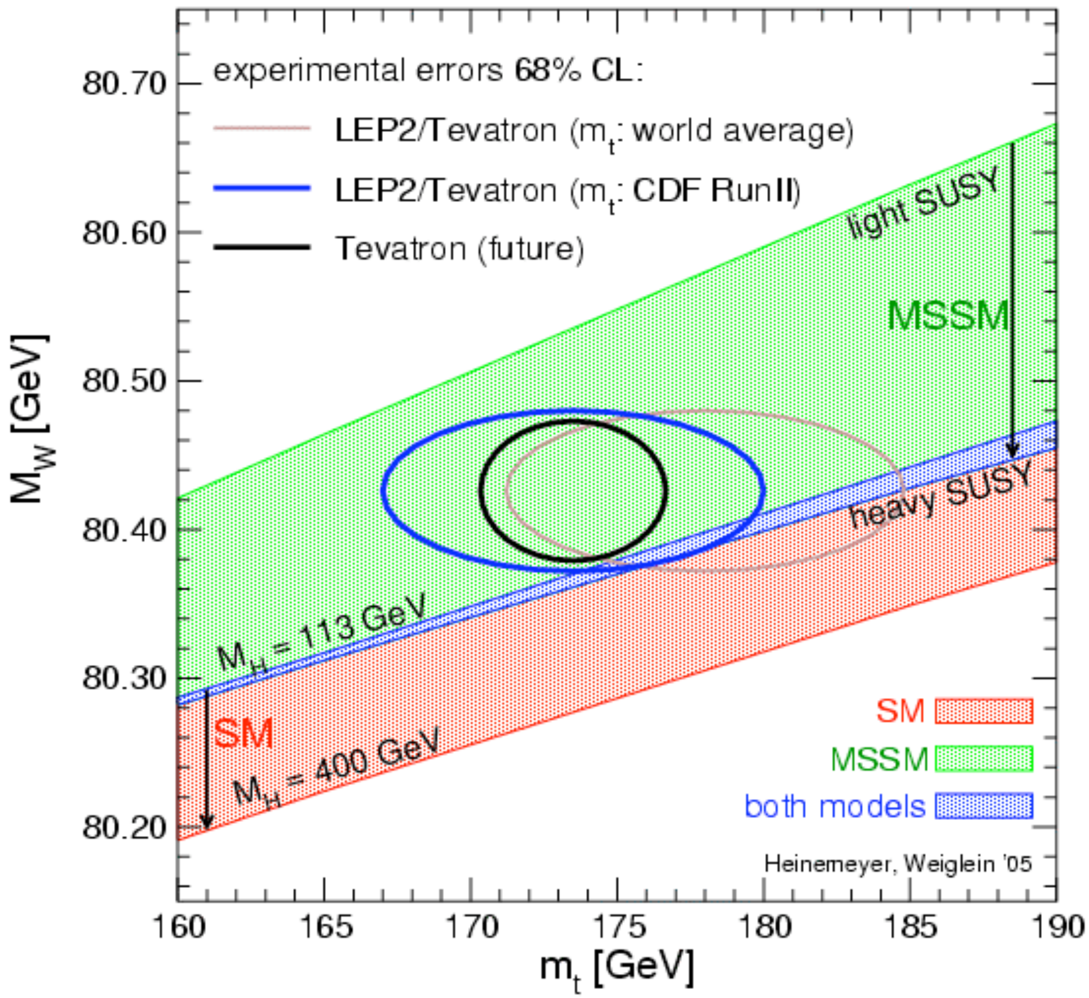








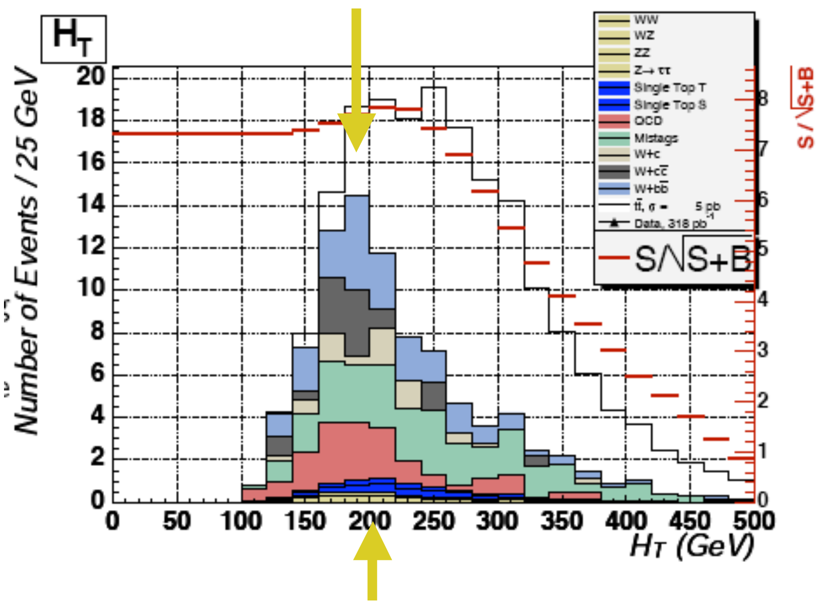



experimental errors 68% CL:
LEP2/Tevatron (m_t: world average)
LEP2/Tevatron (m_t: CDF RunII)
Tevatron (future)
light SUSY
MSSM
heavy SUSY
M_H = 113 GeV
SM
M_H = 400 GeV
SM
MSSM
both models
Heinemeyer, Weiglein '05
80.70
80.60
80.50
80.40
80.30
80.20
M_W [GeV]
160
165
170
175
180
185
190
m_t [GeV]

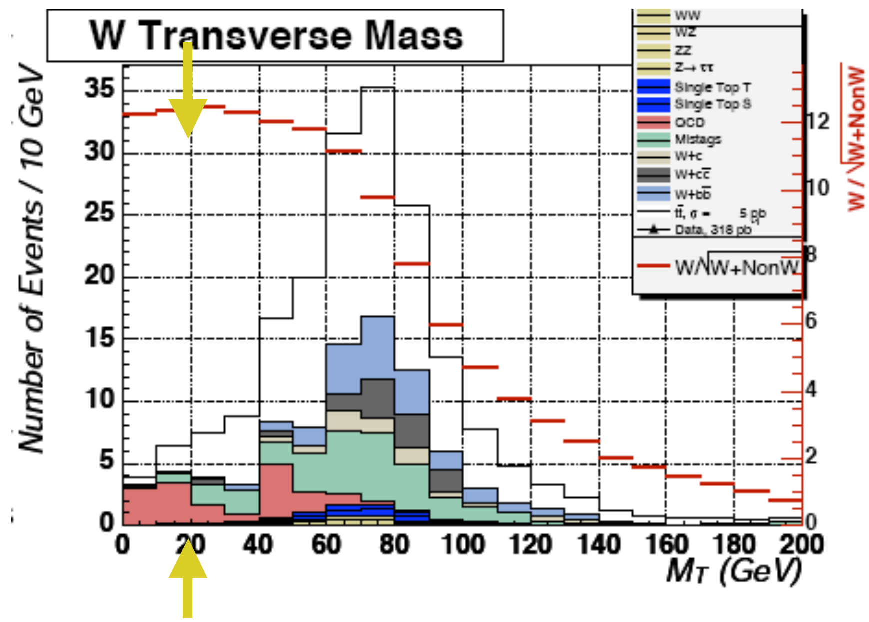
Optimized lepton+jet top analysis

Improve Signal, S/sqrt(S+B), ΔB:

- **Signal:** more statistic (700 pb^{-1}), tagger improved
- **S/√(S+B):** Re-optimize cut on H_T as in previous analysis
- **Background Error:** Reduce error on poorly-modeled QCD fakes by cutting out a lot of these backgrounds: $M_T(W)$ cut



H_T> 200 GeV Optimal



$M_T(W)$ > 20 GeV Optimal

$e\tau_h$ and $\mu\tau_h$ missing energy+jets

$$A \times BR(t\bar{t} \rightarrow e\tau_h, \mu\tau_h) \approx 0.08\%$$

1 isolated electron/muon p_T>20 GeV/c
- ✓ 1 isolated $\tau \rightarrow \upsilon_\tau + hadrons$ p_T>15 GeV/c
- ✓ MET>20 GeV
- ✓ At least 2 jets p_T>20 GeV/c

Reduce backgrounds
- ✓ Total transverse energy >205 GeV
- ✓ Not compatible with $Z \rightarrow \tau\tau$

Events (195 pb^{-1})	$e\tau_h$	$\mu\tau_h$
Bkg	0.8±0.1	0.5±0.1
Data	2	0

CDF set limit on anomalous decay rate

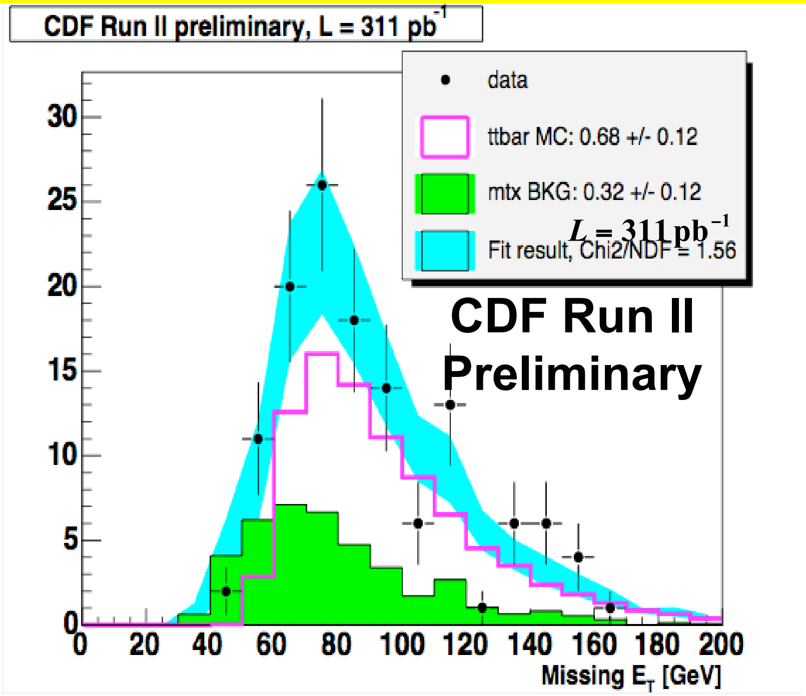
$$\frac{\Gamma(t \rightarrow \tau\upsilon_\tau q)}{\Gamma_{SM}(t \rightarrow \tau\upsilon_\tau q)} < 5.2 \ @ \ 95\% \ \mathrm{C.L.}$$

$$A \times BR(t\bar{t} \rightarrow \nu + jets) \approx 4\%$$

Zero isolated electrons/muons!
- ✓ At least 4 jets p_T>15 GeV/c
- ✓ MET significance > 4 GeV
- ✓ MET not collinear with jets
- ✓ At least 1 b-tag

In future: explicit tau identification!

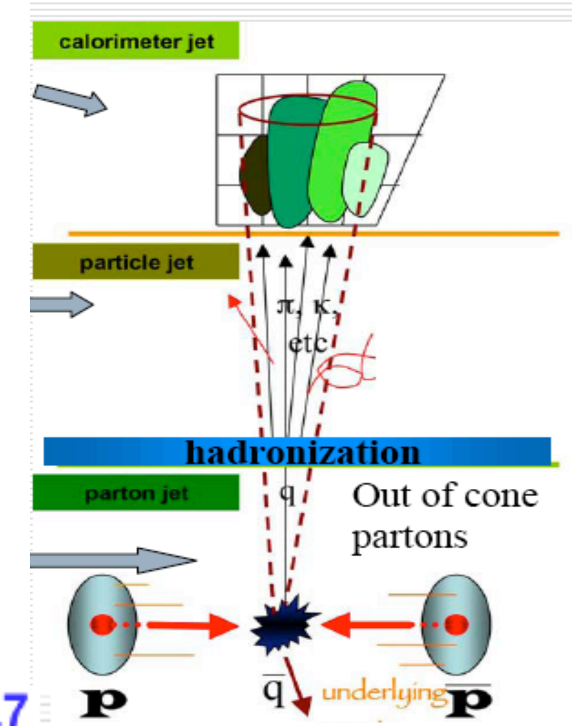
$$\sigma(t\bar{t}) = 6.1 \pm 1.2(\mathrm{stat}) \pm^{1.3}_{0.9}(\mathrm{syst}) \pm 0.4(\mathrm{lumi})\,\mathrm{pb}$$

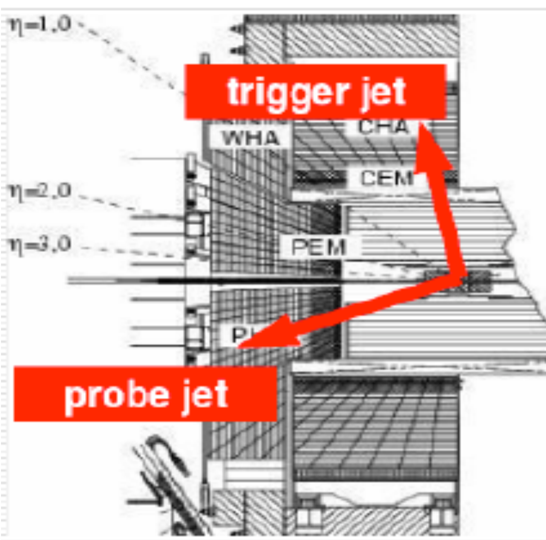


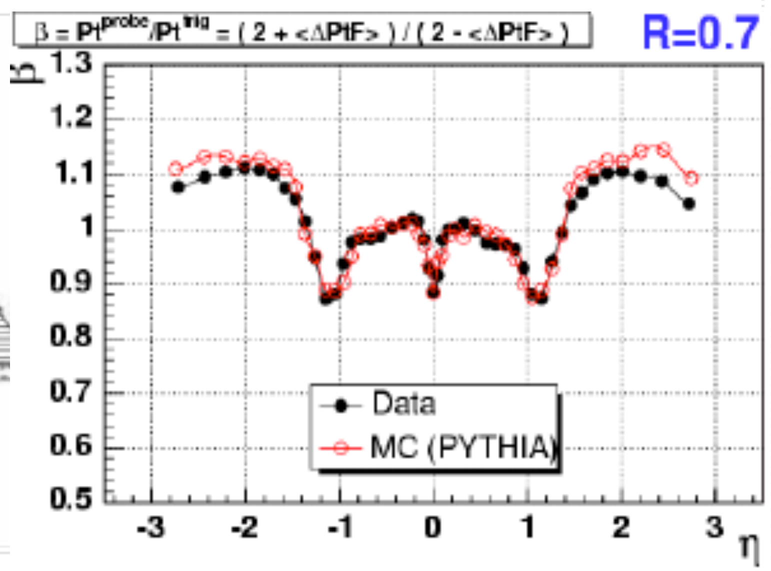
Jet correction

Correction for detector effects:

- Energy scale in the central with test beam, tracking
- transfer energy scale in the forward with jet P_T balance
- Use tuned simulation to correct for underlying event, out of cone radiation ………







Electrons :

$$\frac{\sigma_{E_T}}{E_T} = \frac{13.5\%}{\sqrt{E_T}} \oplus 1.5\% \quad \text{(CEM)}$$

$$\frac{\sigma_E}{E} = \frac{16\%}{\sqrt{E}} \oplus 1\% \quad \text{(PEM)}$$

Pions :

$$\frac{\sigma_E}{E} \approx \frac{80\%}{\sqrt{E}}$$

W mass uncertainty

Systematic uncertainty on transverse mass fit

Uncertainty	Electrons	Muons	Common
Lepton Scale	50	21	21
Lepton Resolution	7	12	0
Recoil Scale	20	20	20
Recoil Resolution	24	24	24
Lepton Removal	15	10	10
ull Efficiency	7	7	0
Backgrounds	17	18	0
pT(W)	13	13	13
PDF	15	15	15
QED	15	20	12
W width	12	12	12
Total Systematic	70	55	48
Statistical	43	49	0
Total	82	74	48