Measurement of the top quark mass in the dilepton channel using m_{T2} at CDF

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Outline

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- Generalization of transverse mass
- Measurement of m_{T2}
- Monte Carlo simulation
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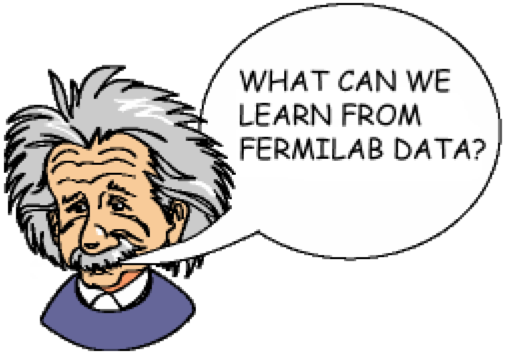
- Conclusion and result

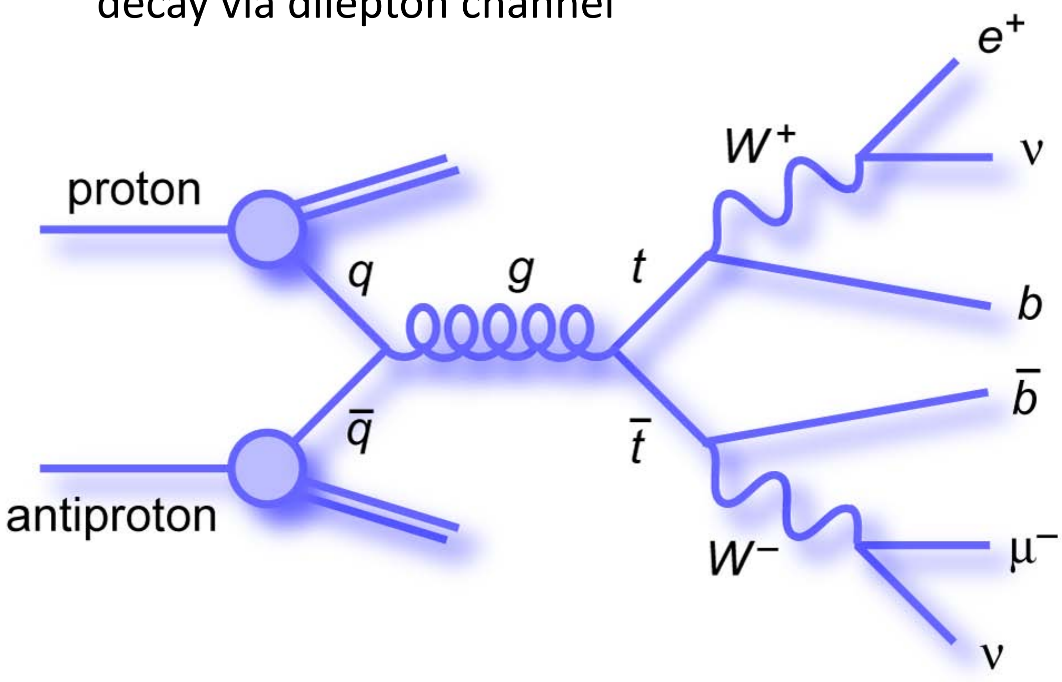
Motivation

- Constrain on Higgsmass with precise topmass (ttbar to Higgs,Wtb-vertex)
- Mt2 sensitive for new physics (dark matter)
- Testing SM at high energy scale



Top quark decay channels

Feynman Diagramm for the top decay via dilepton channel



Looking at final state:

- 2 jet;
- 4 leptons

2 charged leptons

2 neutrinos

Missing transverse energy and missing transvers momentum

We only know $\mathbf{p}_{\mathrm{T,miss}} = \mathbf{p}_{\mathrm{T}}^{(1)} + \mathbf{p}_{\mathrm{T}}^{(2)}$

Generalization of transverse mass

Transverse mass is observable, define as

$$m_T^2 = (E_{T_1} + E_{T_2})^2 - (\vec{p_{T_1}} + \vec{p_{T_2}})^2$$

Can use m_T in decay with one missing energy / momentum

↓

In the decay with two missing energy / momentum we use a generalization of m_T

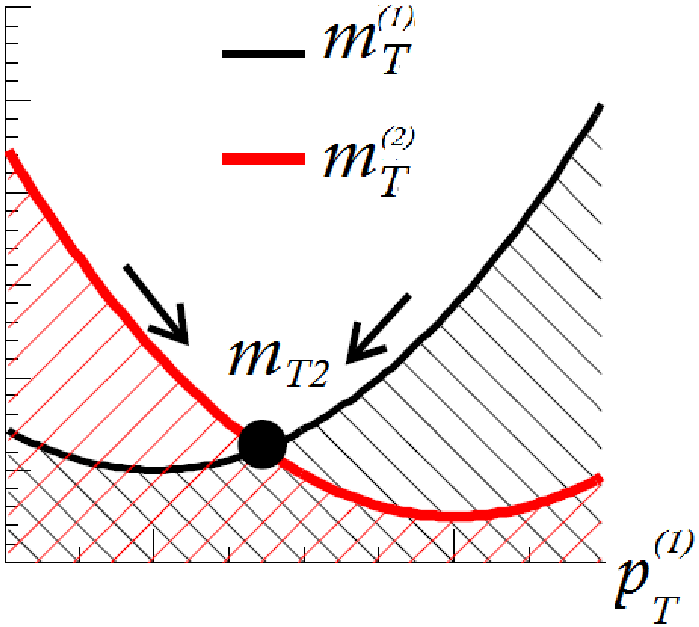
$$m_{T2}(m_{inv}) = min_{p_T^{(1)}, p_T^{(2)}}(max\ (m_T(m_{inv},\ p_T^{(1)}),\ m_T(m_{inv},\ p_T^{(2)})))$$

m_{T2} for one event

To calculate m_{T2} we need to consider all combinations:

1. Jet 1 connects to lepton 1 and Jet 2 connects to lepton 2
2. Jet 1 connects to lepton 2 and Jet 2 connects to lepton 1

We take first one combination and calculate m_{T2} , as in the picture

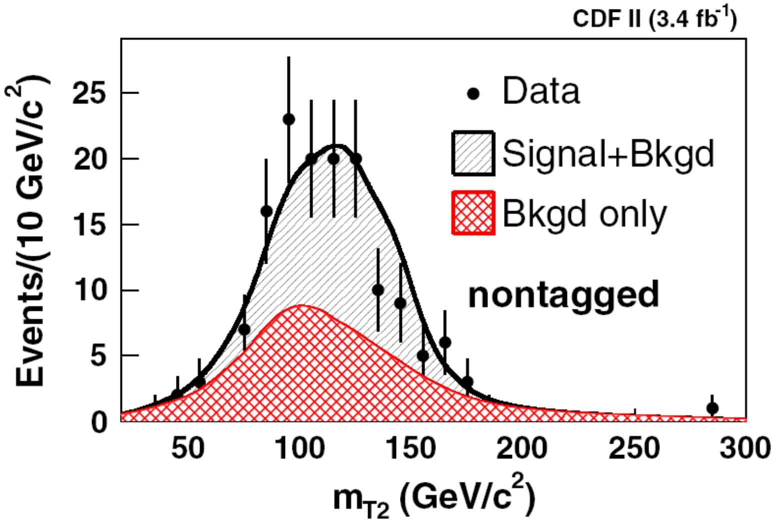


$$\mathbf{p}_{\mathbf{T},\mathbf{miss}} = \mathbf{p}_{\mathbf{T}}^{(\mathbf{1})} + \mathbf{p}_{\mathbf{T}}^{(\mathbf{2})}$$

$p_T^{(1)}$ goes from 0 to $\mathbf{p}_{\mathbf{T},\mathbf{miss}}$

Then we make the same thing for the other combination and we take the smaller m_{T2}

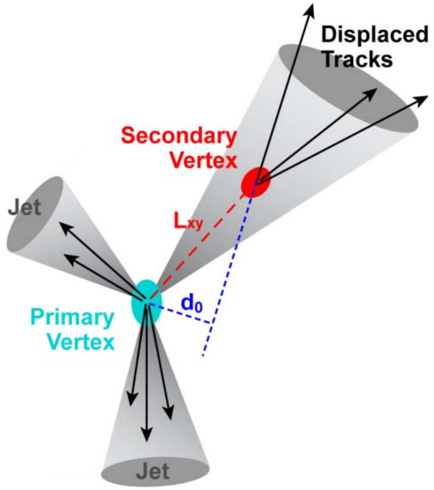
m_{T2} for all events

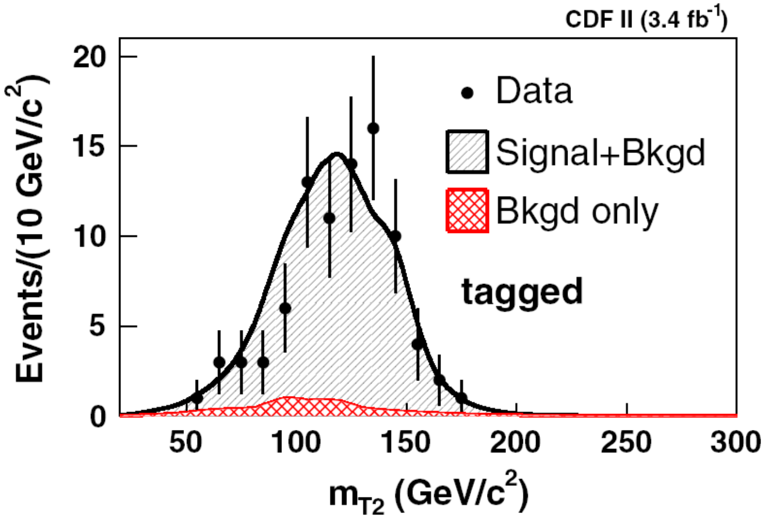


With $3.4\ fb^{-1}$ luminosity achieve mT2 distribution in range of 0 to 300 GeV

The MC signal+background are included and fitted.

If we consider b tagging, the background and uncertainty in data will be reduced





Monte Carlo simulation

For full background simulation, we start with

PDFs from other experiments, use KDE (kernel density estimator)

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76 t t MC samples with fixed M_{top} from 130 to 220 GeV

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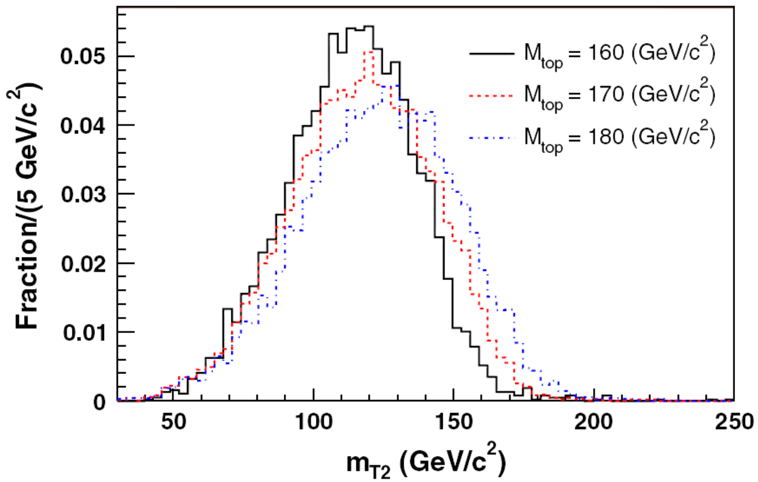
Likelyhood fit to “measured” mT2

↓

Best fit to the data: M_{top} =168 GeV



Systematic uncertainties

The highest uncertainty is due to jet energy scale (light quarks). This comes from modeling of b-fragmentation, b hadron branching fractions and calorimeter response

TABLE II. Estimated statistical ($M_{top} = 175$ GeV/c^2), systematic, and total uncertainties in GeV/c^2.

		m_{T2}
Statistical		4.0
Systematic	Jet energy scale (light quarks)	2.6
	Generator	0.3
	Parton distribution functions	0.5
	b jet energy scale	0.2
	Background shape	0.4
	Gluon fusion fraction	0.3
	Initial- and final-state radiation	0.6
	MC statistics	0.3
	Lepton energy	0.6
	Multiple hadron interaction	0.2
	Color reconnection	0.7
	Total systematic uncertainty	2.9
Total		5.0

Conclusion and result

We took $3.4\ fb^{-1}$ of CDF data in $p\bar{p}$ collision with $\sqrt{s} = 1.96\ TeV$

From these 236 $t\bar{t}$ events with the dileptonic signature were selected

Using m_{T2} :

$$M_{top} = 168\ \pm^{4.8}_{4.0}\ (stat)\ \pm\ 2.9\ (syst)\ GeV/c^2$$

With m_t^{NWA} (Neutrino weighted algorithm) and m_{T2} :

$$M_{top} = 169.3\ \pm 2.7\ (stat)\ \pm\ 3.2\ (syst)\ GeV/c^2$$

The systematic uncertainties of M_{top} using m_{T2} are lower than previous measurement in single lepton channel, this makes m_{T2} to one of the best observables for the topmass.