A method of extracting the mass of the top quark in the di-lepton channel using the DØ Detector

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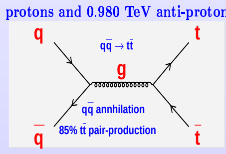
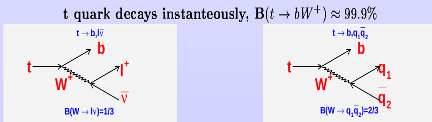
In the $t\bar{t} \to bl_1^+\nu_{l_1}\ \bar{b}l_2^-\bar{\nu}_{l_2}$ decay channel the two neutrinos remain undetected. Extraction of the mass of the top quark by kinematic reconstruction is not possible because the event is underconstrained. In this poster we illustrate a method of extracting the mass of the top quark from an ensemble of simulated events.

DØ RunI di-lepton channel $m_t = 168.1 \pm 12.3$ (stat) ± 3.6 (sys) GeV
current world average $m_t = 178.0 \pm 4.3$ GeV

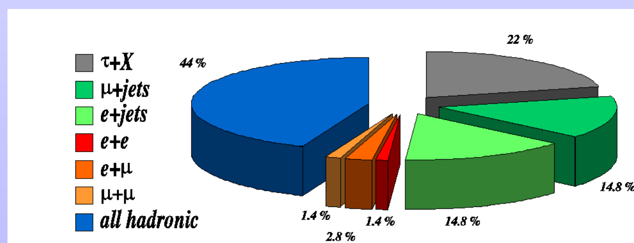
0.980 TeV protons and 0.980 TeV anti-protons collide ..



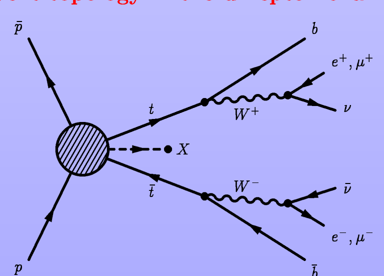
t quark decays instantaneously, $B(t \to bW^+) \approx 99.9\%$



W^+W^- decay products characterize the $t\bar{t}$ final state



Event topology in the di-lepton channel



$t\bar{t} \to l_1, l_2, \nu_1, \nu_2, b_1, b_2$

In a nutshell ..

- 6 particle final state, but only 4 objects detected
- unbalanced Σp_{Tx}, Σp_{Ty} obtained
- $m(l_1, \nu_1) = m_W = m(l_2, \nu_2)$
- $m_t(b_1, l_1, \nu_1) = m_{\bar{t}}(b_2, l_2, \nu_2)$

$\Rightarrow$ an underconstrained problem

- hypothesized m_t used to solve for $t\bar{t}$ momenta
- get 2 quadratic equations for each ν momenta, and
- obtain upto 4 real solutions for $t\bar{t}$ momenta, with 2-fold jet combinatoric ambiguity.

RunI Algorithm[1]- an extension of the idea by:-
K. Kondo[2], and *R. H. Dalitz*, *G. R. Goldstein*[3],

[1] PRL 80, 2063 (1998), PRD 60, 05 2001 (1998).
[2] J. Phys. Soc. Jpn. 57, 4126 (1988)
[3] PRD 45, 1531 (1992).

for a range of hypothesized m_t a weight distribution corresponding to the final state observables is generated per event

for each solution, weight:

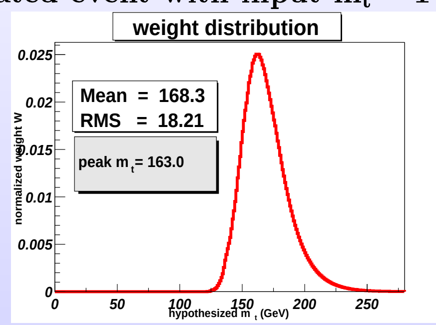
$$\mathcal{W}_i(m_t) \propto f(x1)f(x2)p(E'|m_t)p(\bar{E}'|m_t),$$

$f(x1)$ is the proton parton distribution function at momentum fraction $x1$, $p(E'|m_t)$ is the probability of lepton energy being E' in the rest frame of the t quark of mass m_t

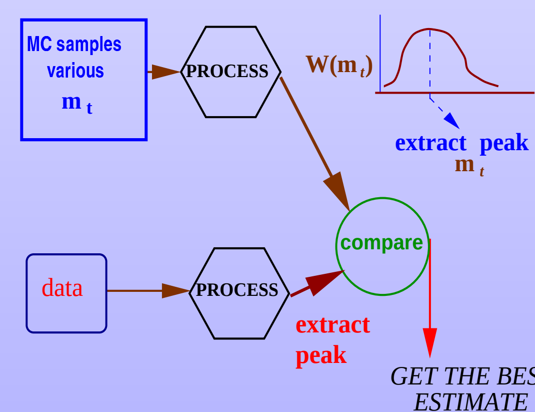
using all solutions, the event weight:

$$W(m_t) = \sum \mathcal{W}_i(m_t)$$

normalized weight distribution $W(m_t)$, for a simulated event with input $m_t = 175$ GeV

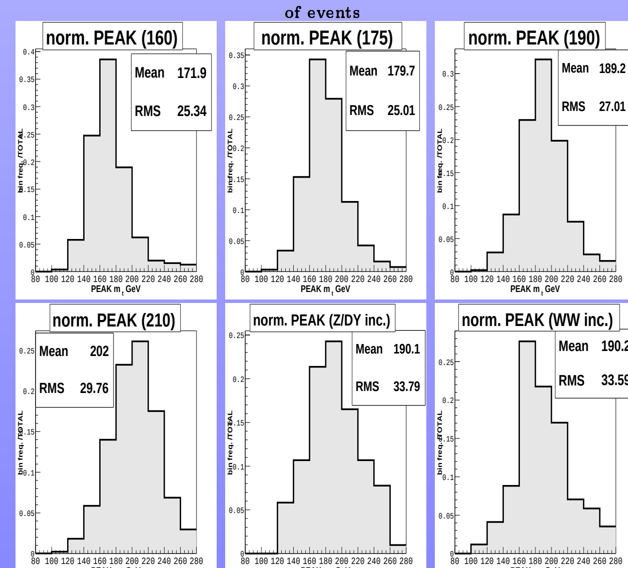


This is the likelihood distribution corresponding to a range of hypothesized m_t. The most likely $m_t = 163.0$ GeV.



normalized likelihood distributions
emu channel

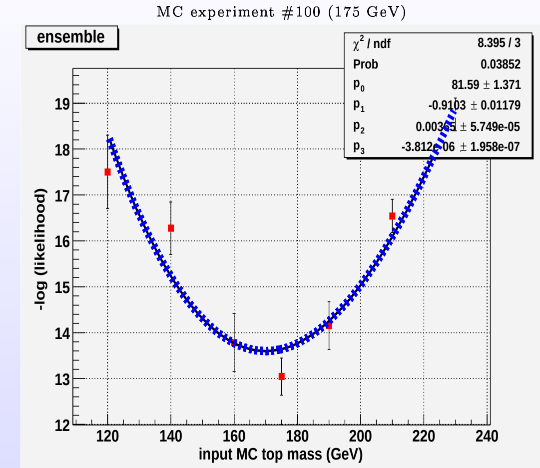
histograms of the peak m_t of the weight distributions for some signal and background classes of events



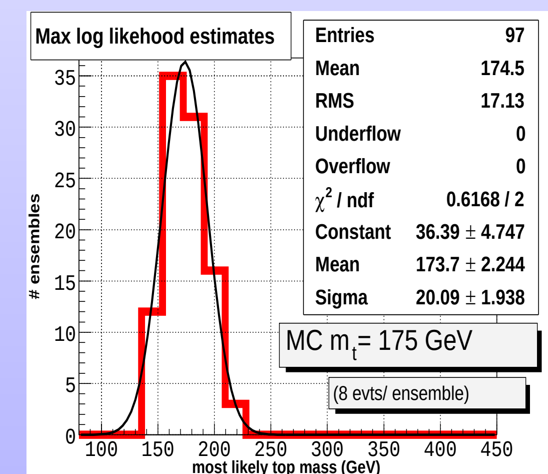
log-likelihood plot and m_t estimation

8 events (142.73 pb^{-1}) in emu channel, sig:bkg $\approx 4:1$
binned likelihood fit is done to compare the likelihood distributions from MC to the simulated data.

MC experiment #100 (175 GeV)

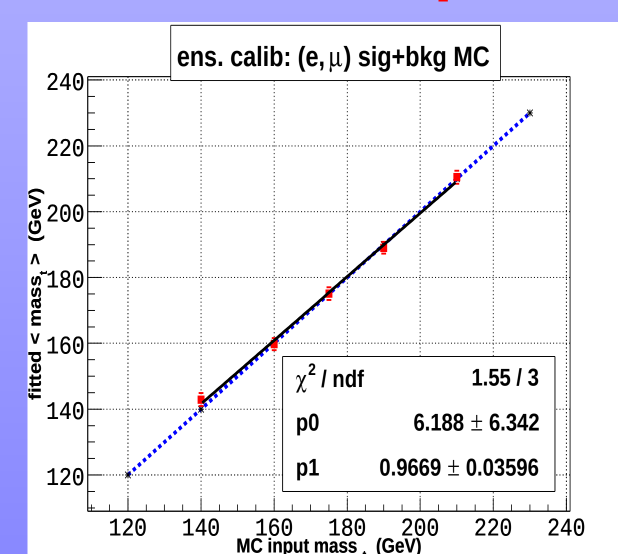


max. log-likelihood estimate distributions



the most likely m_t obtained from simulated ensembles
sig:bkg composition of the 8 event ensembles $\approx 4:1$

MC Calibration verifies performance



average most likely m_t as a function of input MC m_t