Top quark mass reconstruction

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Introduction to Terascale Physics

25.02.2011

The top quark

- 3. generation of quarks

  (postulated by Kobayashi&Maskawa to explain CP violation)

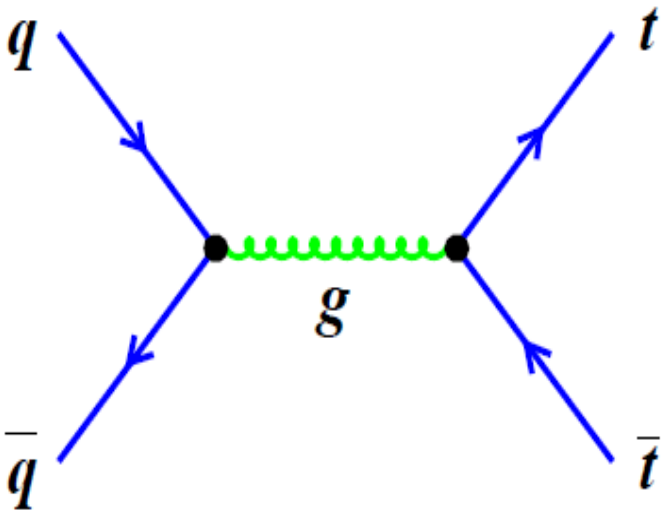
- special properties:
  - heaviest known quark
  - very short lifetime -> decays before hadronization

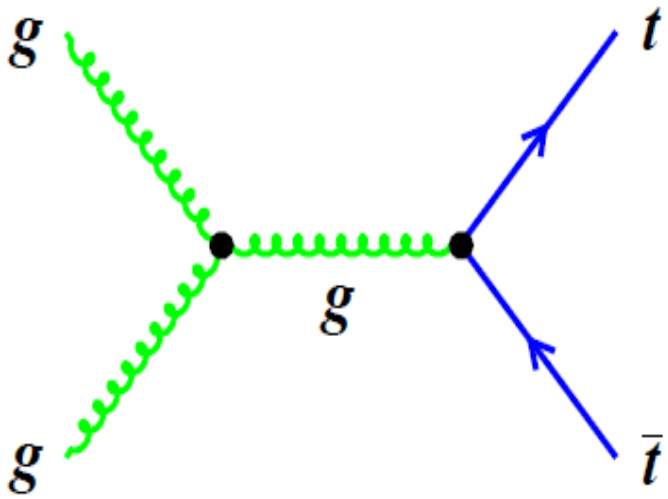
    -> study bare quark main properties spin etc.

- production and decay both sensible to new physics

  -> constraints on Higgs mass

Top production



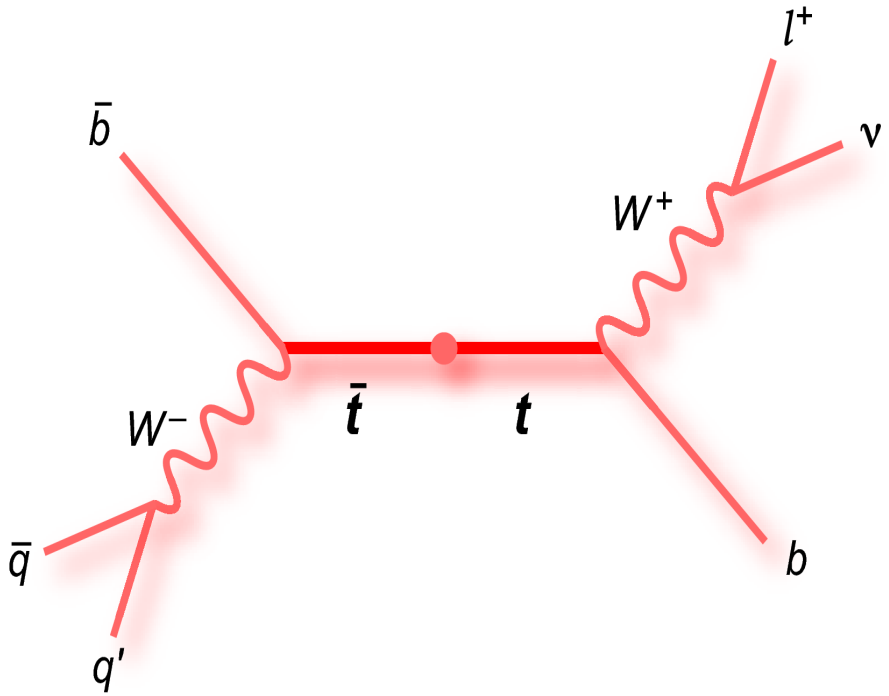


Tevatron: qqbar: 85% gg: 15%

LHC: qqbar: 15% gg: 85%

Top decay and reconstruction

almost 100% of top quarks decay to W + b



Decay modes & signatures:

- Di-leptonic (11%)
  -> 2 (b-) jets
  + 2 charged leptons
  + large missing Et

- Semi-leptonic (44%)
  -> 4 jets (2x b and 2x light jets)
  + 1 charged lepton
  + missing Et

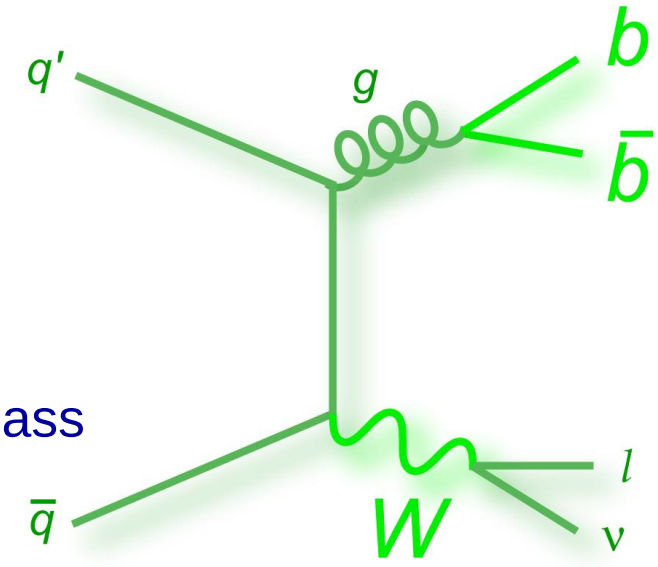
- Hadronic (44%)
  -> 6 jets

⇨ Complex signatures: all detector component used
tools: b-tagging & kinematic fits

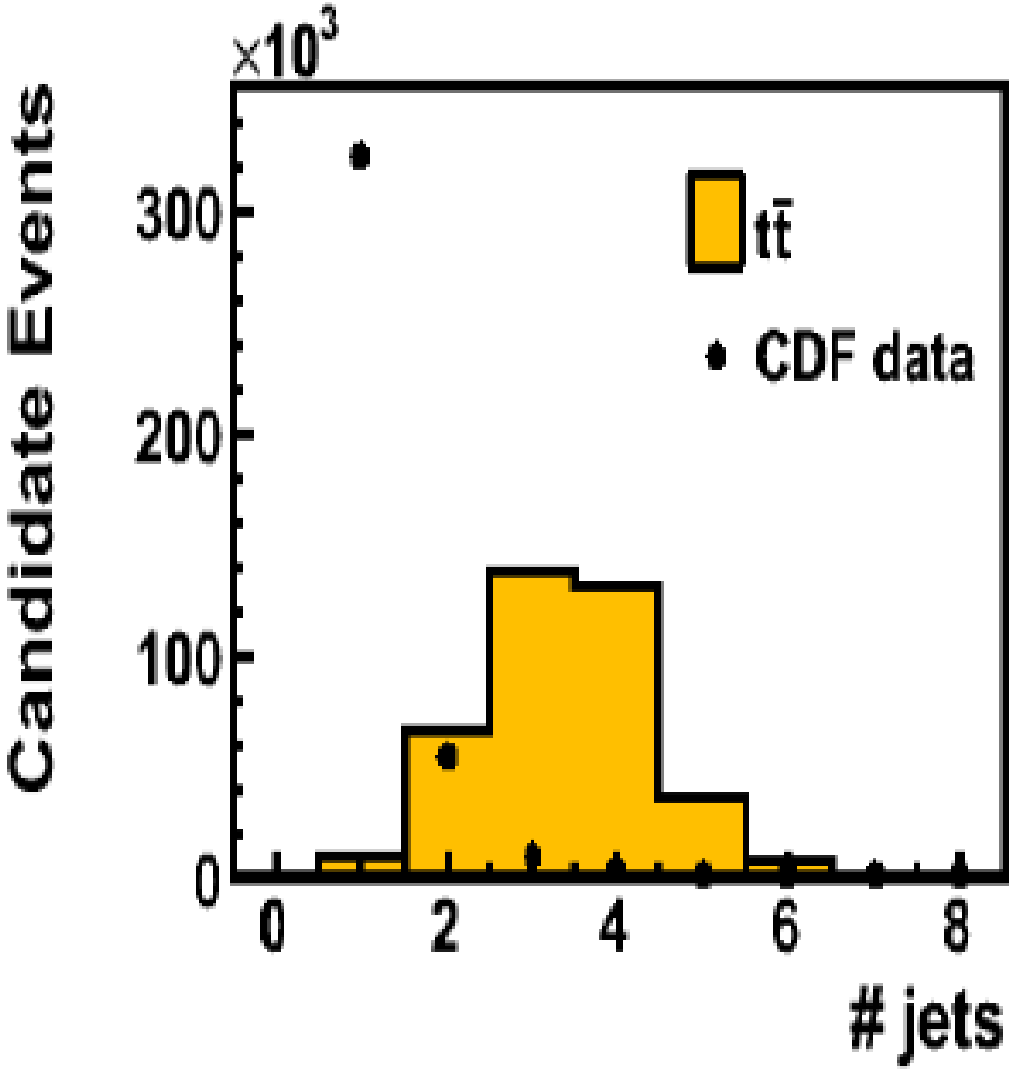
Tutorial on top analysis

Goal:

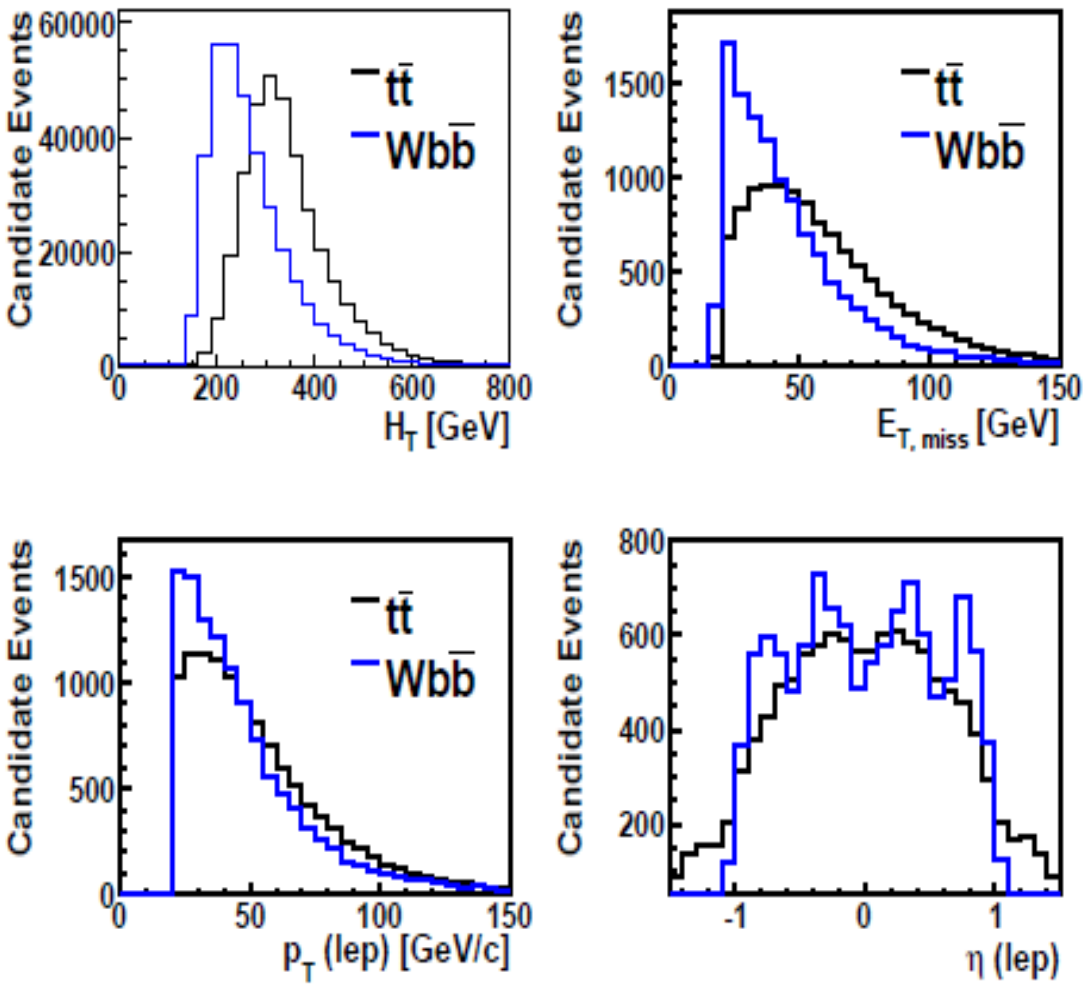
- distinguish real(!) top quark events (CDF data) from QCD and W + Jet events in the semileptonic channel
- perform template fit with tt and Wbb templates
- use calibration (linear t) to determine the top mass



First cuts on jets



Event shape variables



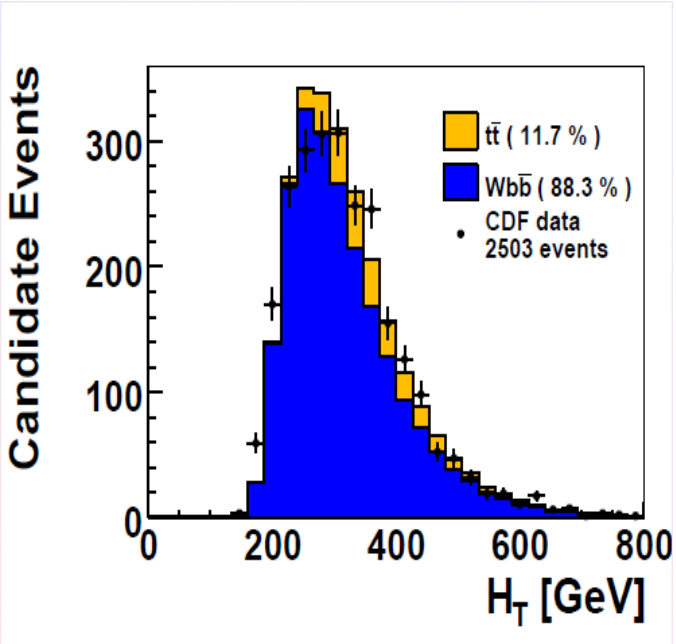
NJets >= 3

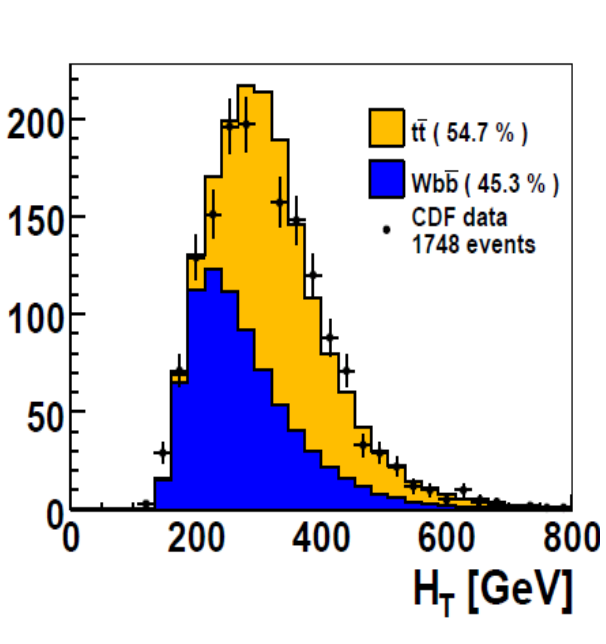
- Best discriminating variable" is HT (scalar sum of all transverse momenta)

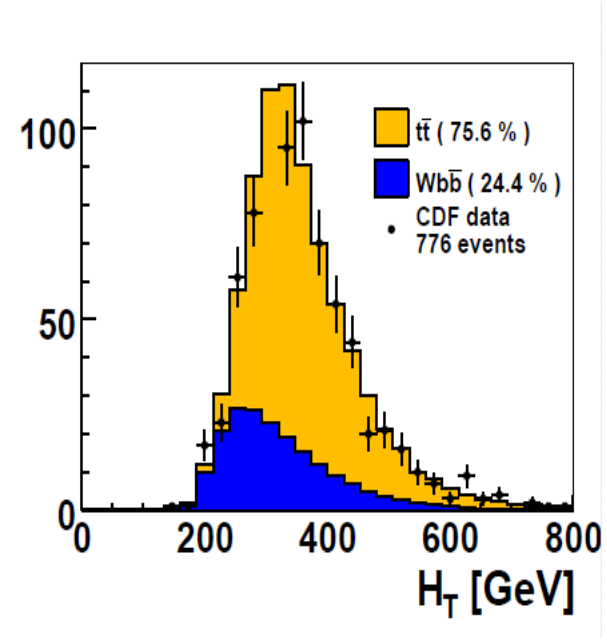
  - large top quark mass decay products have high transverse Momenta

- Extract template from MC distribution for ttbar and Wbb

Template fit



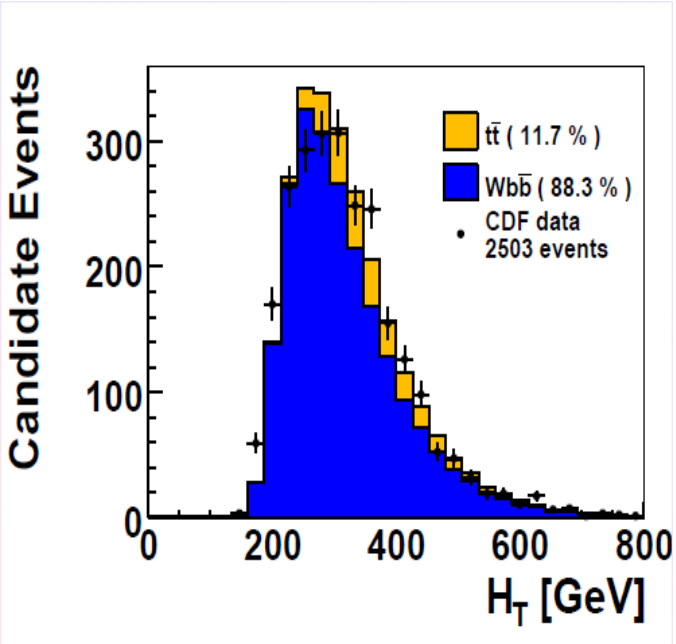


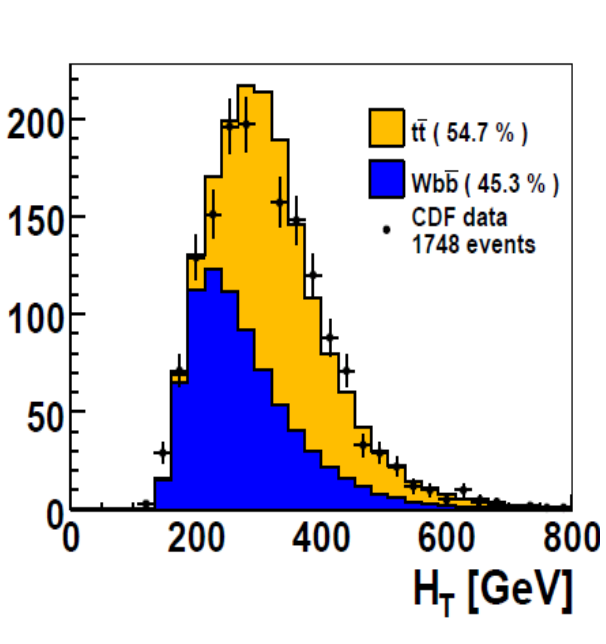


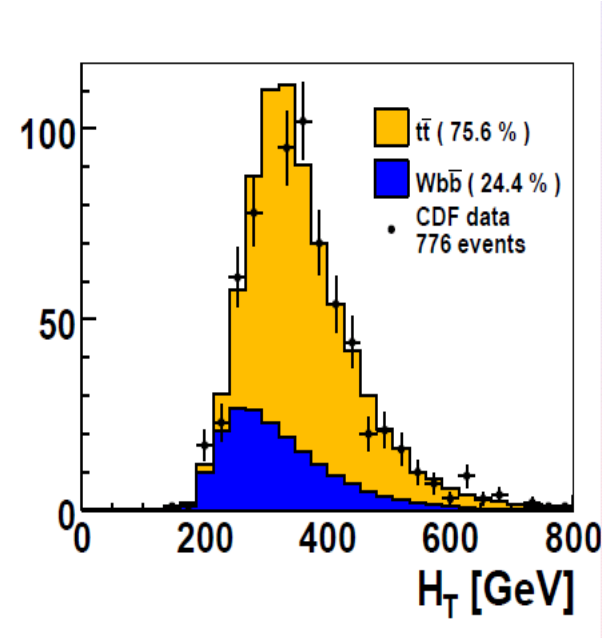
Cuts NJets >= 4 NJets >= 3 & b-tag>=1 NJets >=4 & b-tag >=1

Template fit: - scale MC signal and background to match real data shape
- > fit parameter = scaling factor = signal fraction

Signal fraction

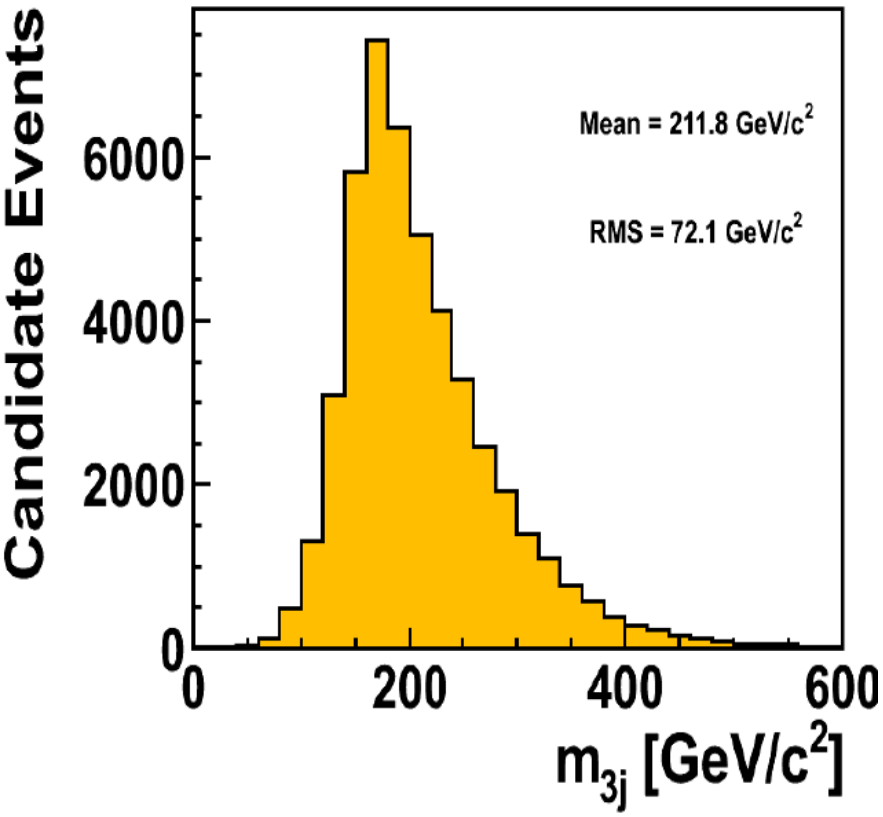


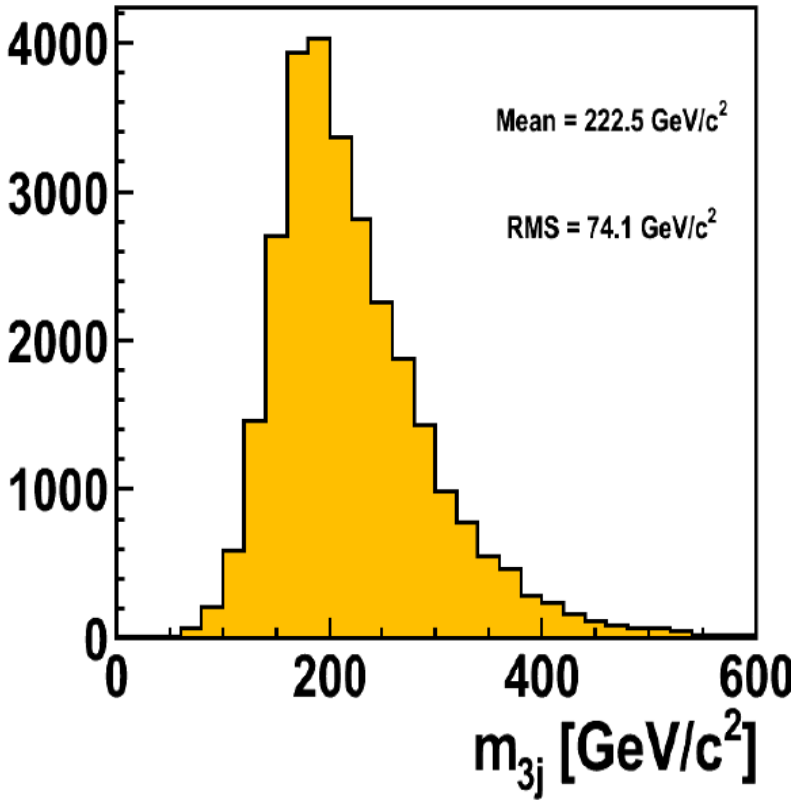




Cuts	NJets >= 4	NJets >= 3 & b-tag>=1	NJets >=4 & b-tag >=1
NEvents	**2503**	**1748**	**776**
Sig.frac.	**0.116**	**0.546**	**0.756**
S/B	**0.13**	**1.21**	**3.1**
$S/\sqrt{B}$	**6.22**	**33.97**	**42.62**

Top mass reconstruction

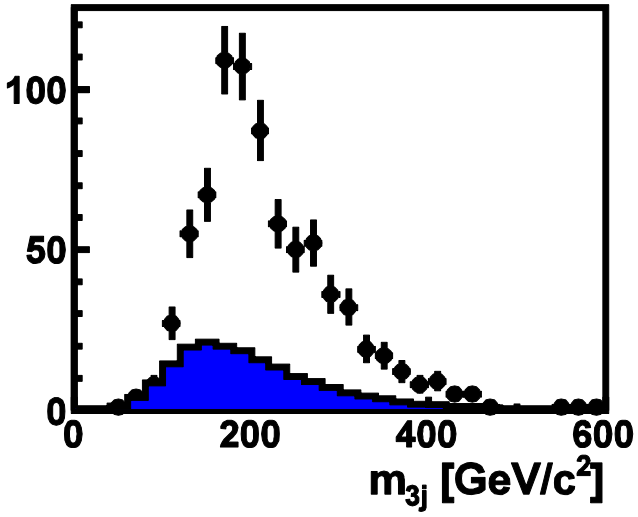


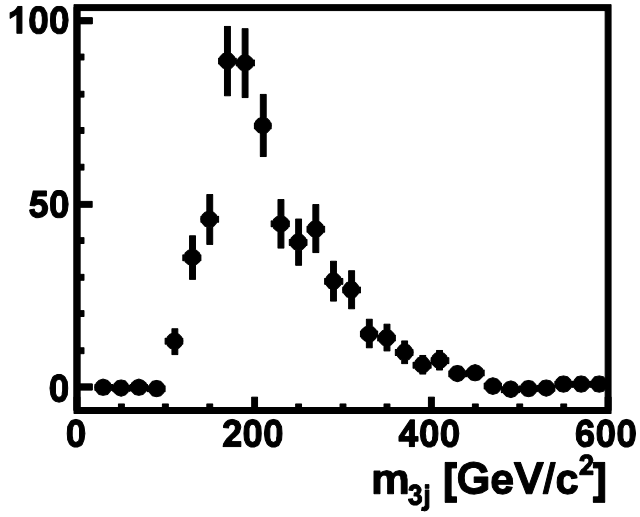


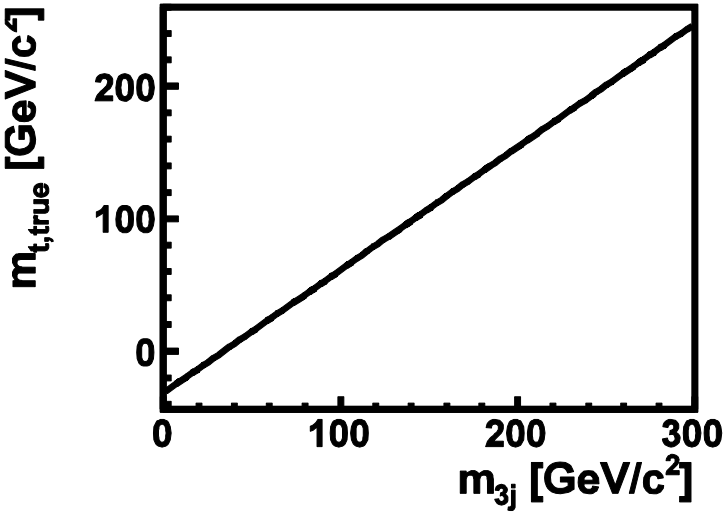
Combination of the 3 jets with highest pT -> invariant mass

CDF RunII : m(top) = 173.1 +-1.1 GeV/c² -> here too high combinatorial background

TRUE top mass reconstruction





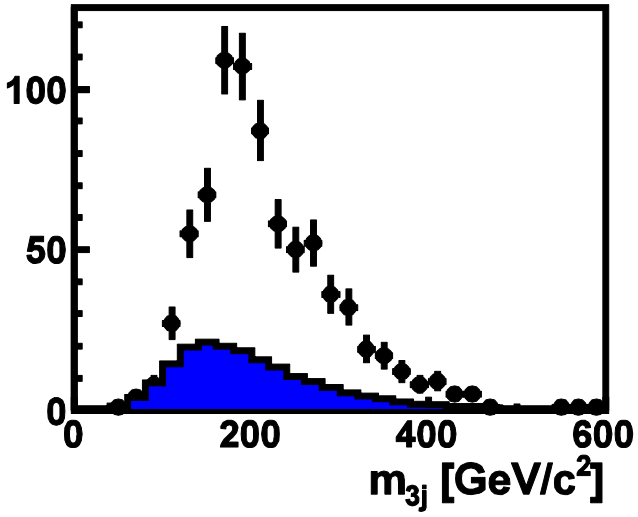


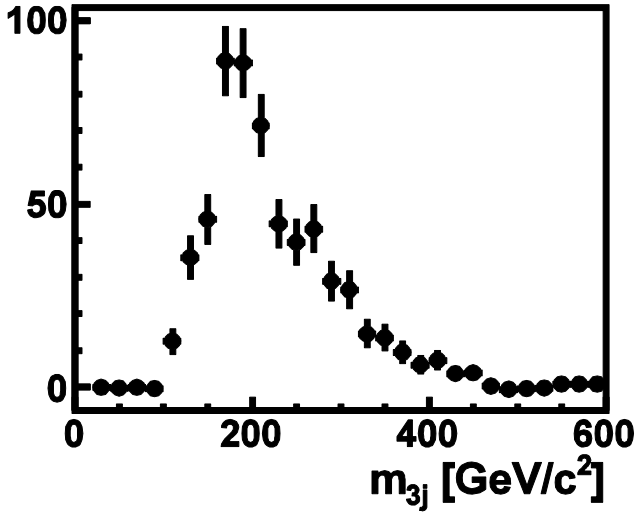
- use signal fraction to subtract background
- assume linear dependence

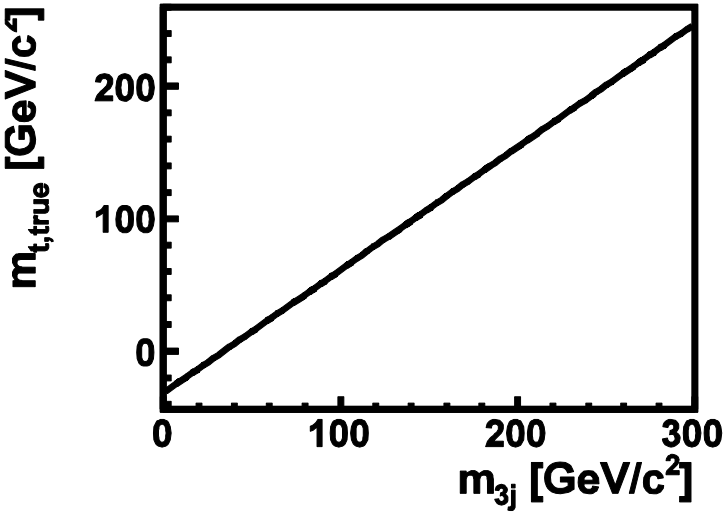
  m(t,true)= a * m(3j) + b

- determine a&b from MC for different m(t,true)

Top mass reconstruction







$$m_{t,true} = 165 GeV/c^2 \rightarrow \hat{m}_{3J} = 211.8 GeV/c^2$$

$$m_{t,true} = 175 GeV/c^2 \rightarrow \hat{m}_{3J} = 222.5 GeV/c^2$$

$$\hat{m}_{3J}(data) = 224.5 GeV/c^2$$

$$m_{t,Data} = 175.8 GeV/c^2$$

Thanks for your time!

Also many thanks to all the organizers and lecturers!