Top Quarks at CDF

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Top physics today and tomorrow

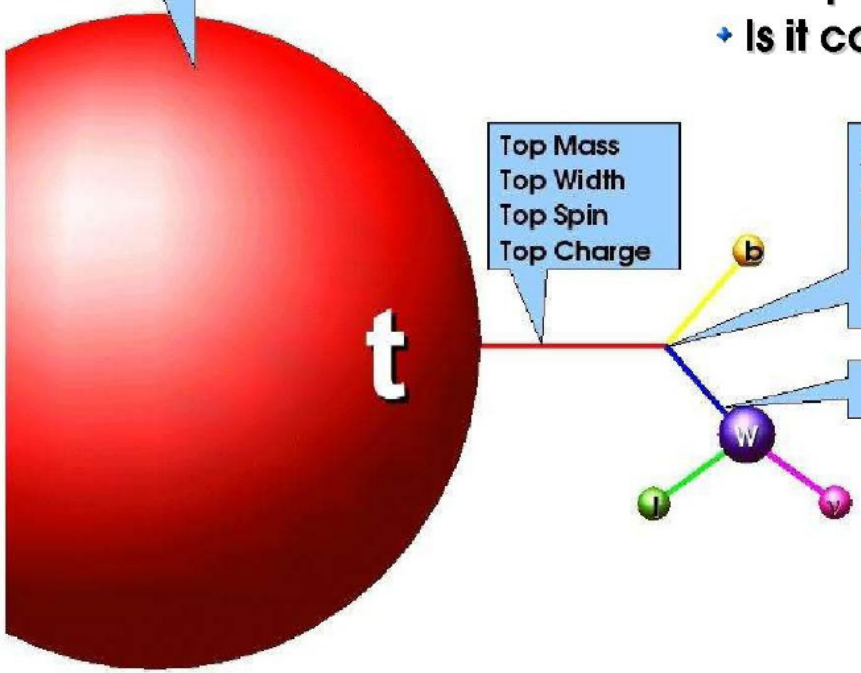
Top Quark Physics

Run I : top quark discovery

- tt Production Cross-Section
- tt Production via interm. Resonances
- Production Kinematics
- Spin Polarization

Run II: with high precision answer ...

- Why is top so heavy ?
- Is top/third generation special ?
- Is top involved in EWSB ?
- Is it connected to new physics ?



- Top Mass
- Top Width
- Top Spin
- Top Charge

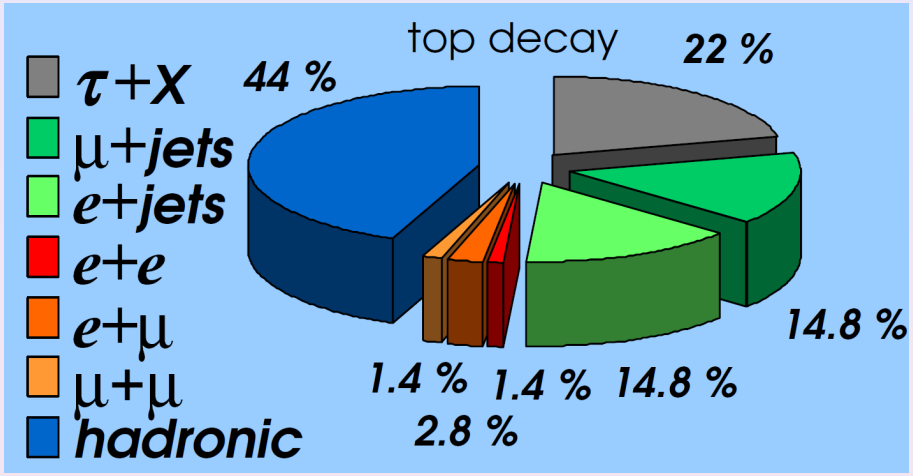
- Anomalous Couplings
- CP Violation
- Rare/non-SM Decays
- Branching Ratios
- $|V_{tb}|$

- W helicity

Why is the Top Quark so interesting ?

- completes the quark sector
- large mass $m_{top} \sim 175\ GeV / c^2$
- short lifetime $\tau \sim 5 \cdot 10^{-25} s \ll \Lambda^{-1}_{QCD}$
- decays before fragmenting
- sensitive to physics beyond the SM

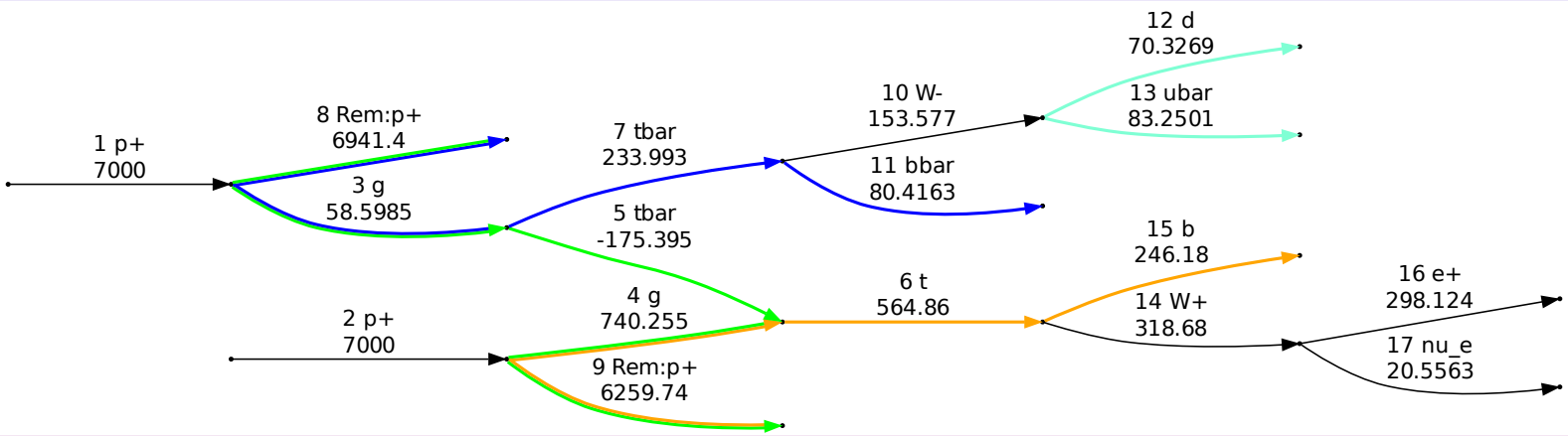
Our top analysis



Here we:

- distinguish real(!) top quark events (CDF data) from QCD and W + Jet events in the semileptonic channel
- perform templatefit with $t\bar{t}$ and $Wb\bar{b}$ templates
- use calibration (linear fit) to estimate the top mass

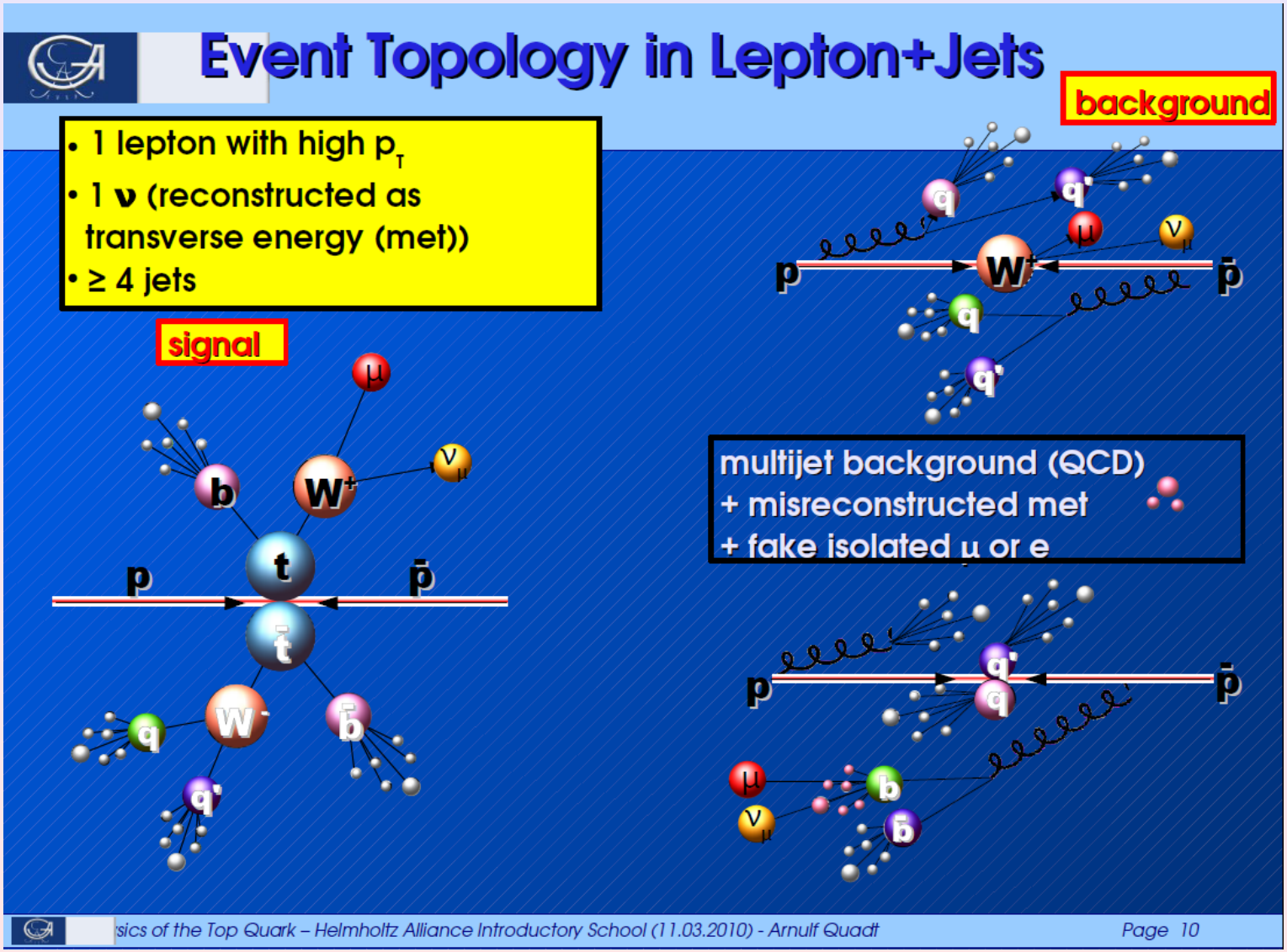
semileptonic $t\bar{t}$ signal and cuts



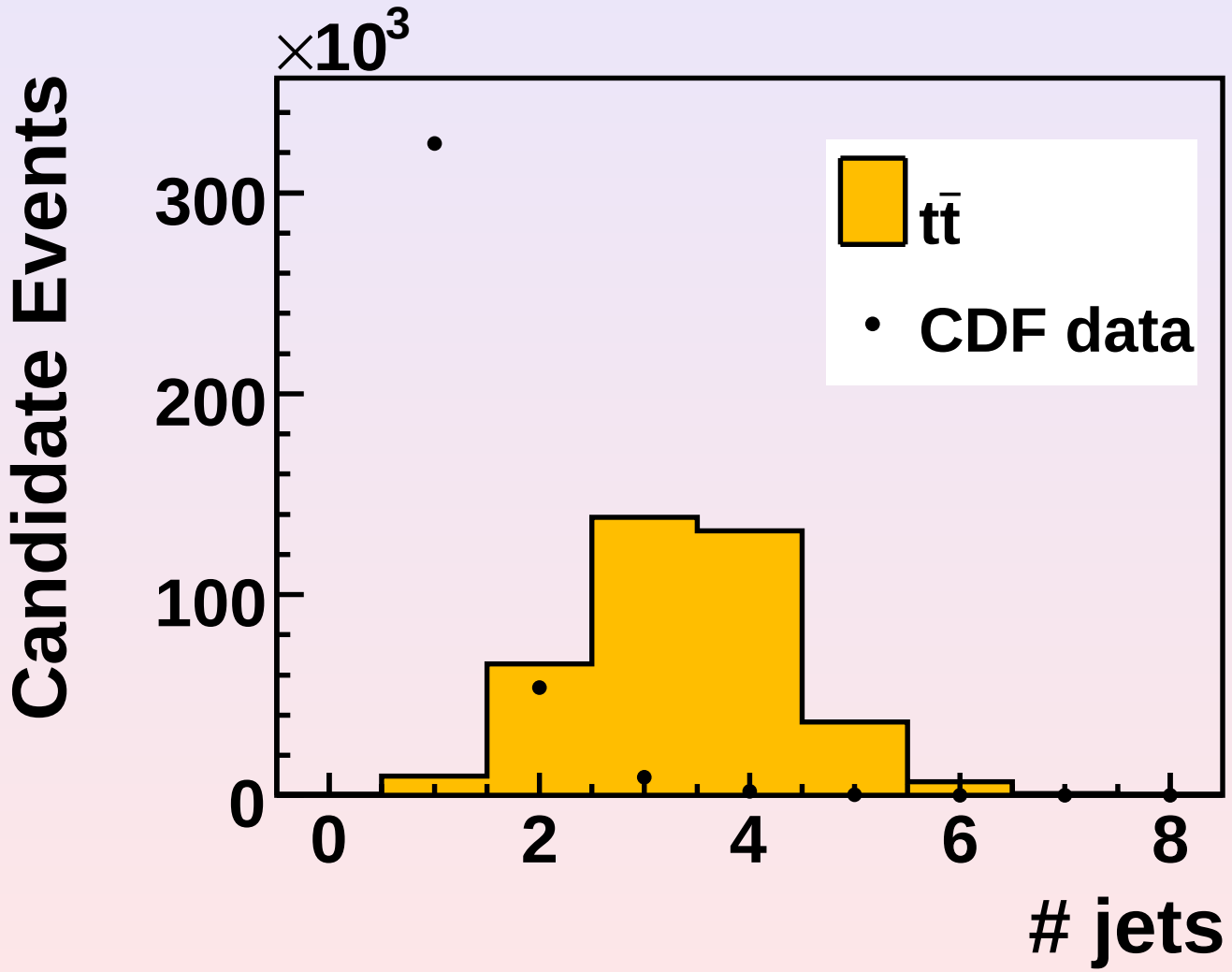
Preselection Cuts

- isolated lepton (i.e. e/mu) with $\mathrm{pt} > 20\mathrm{GeV}$ (reduces QCD background)
- only one isolated lepton; invariant mass of ℓ + "object" $\ncong m_Z$ (reduces Z background)
- require at least one high energetic jet with $E_T > 15\mathrm{GeV}$
- require $MET \geq 20\mathrm{GeV}$

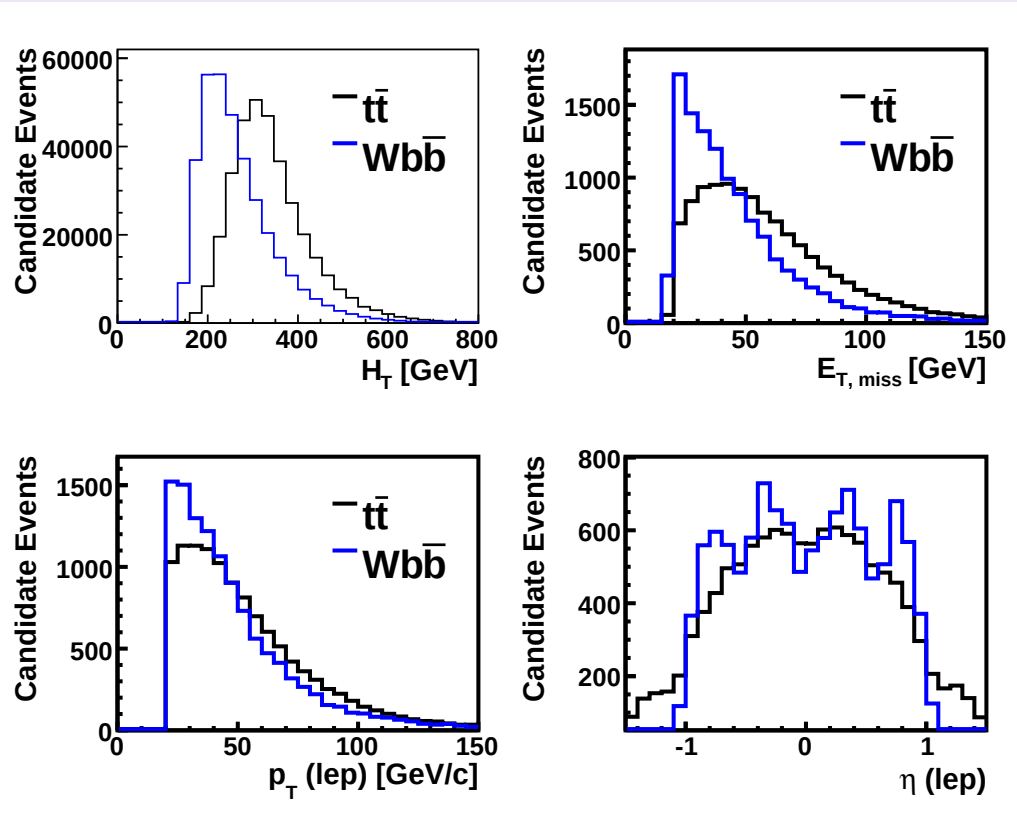
Signal and Background



Which cut on Jets?

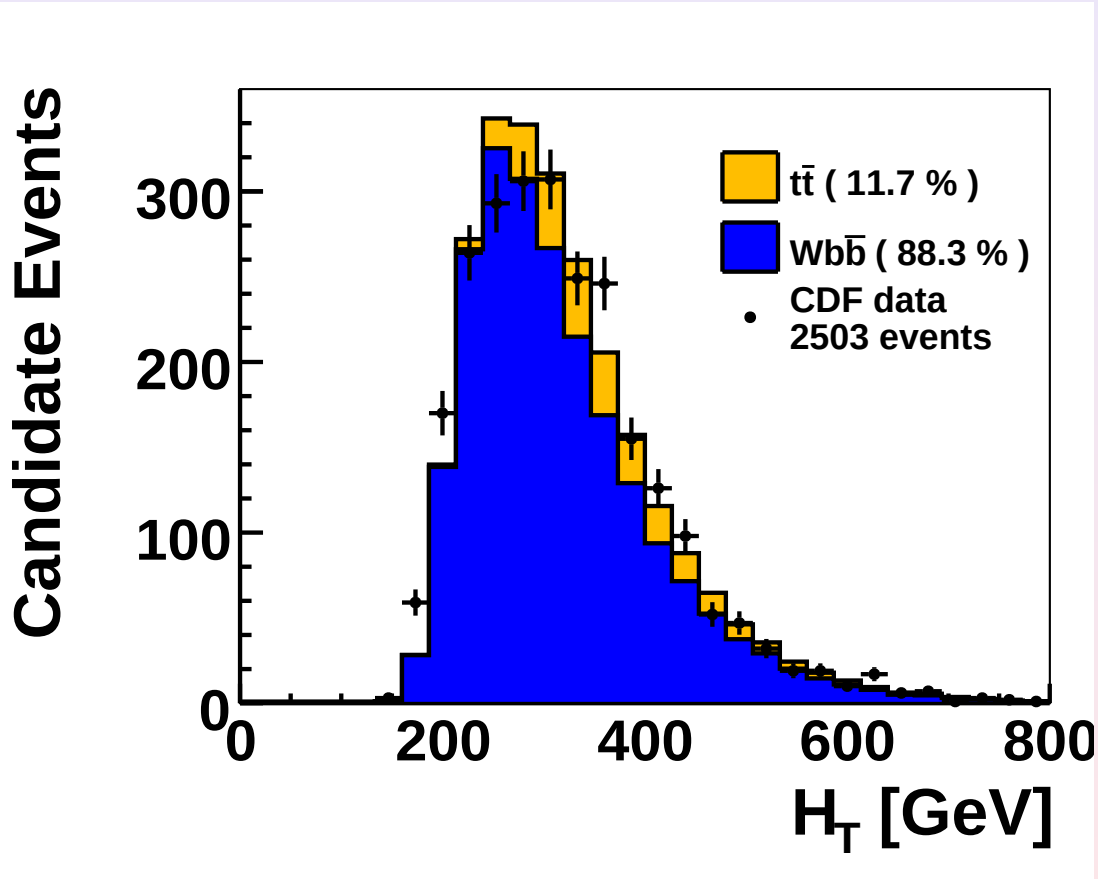


Event Shape, min 3 Jets

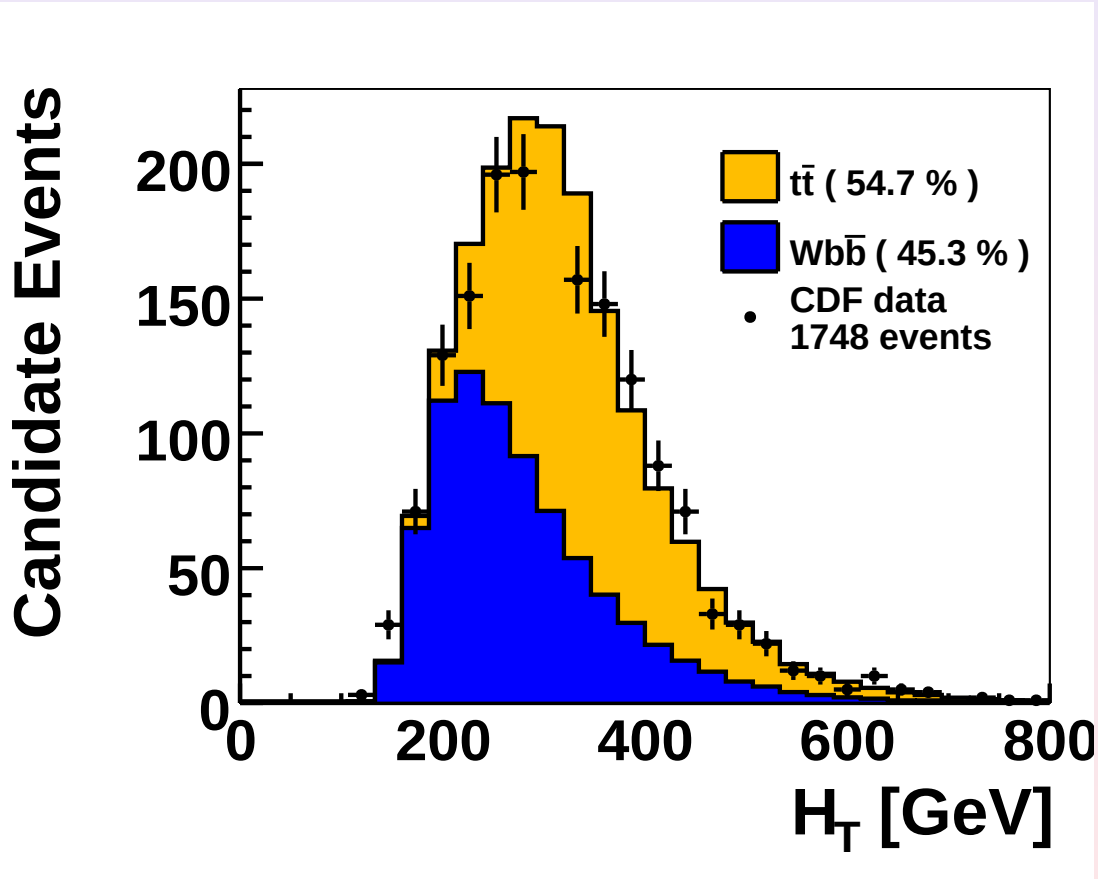


- "Best discriminating variable" is H_T(scalar sum of all transverse momenta)
  - large top quark mass $\rightarrow$ decay products have high transverse momenta
- Extract template from MC distribution for ttbar and $Wb\bar{b}$

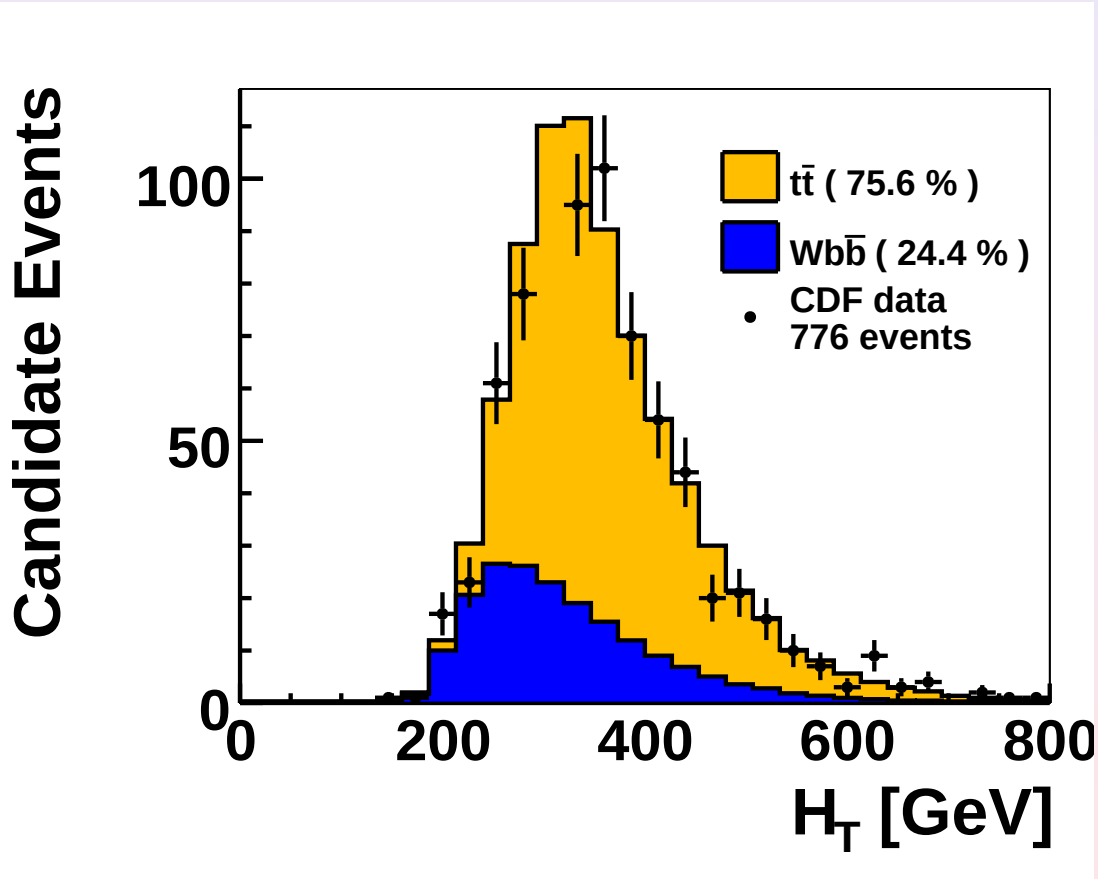
Discriminating Variable H_T, Template Fit for $N \geq 4$



Discriminating Variable H_T, Template Fit for $N \geq 3$ and min 1 b-tagged jet



Discriminating Variable H_T, Template Fit for $N \geq 4$ and min 1 b-tagged jet

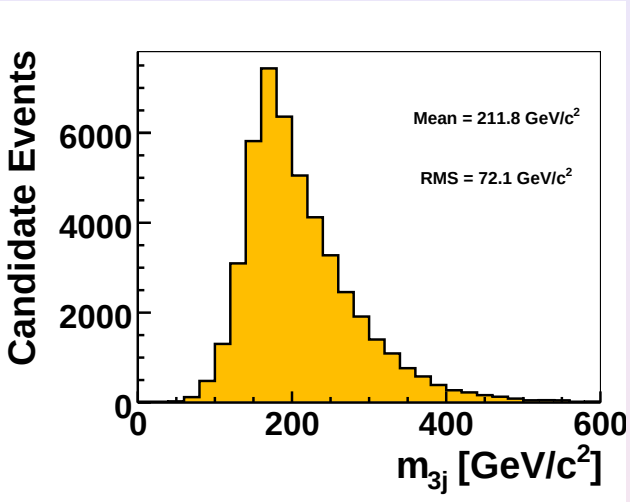


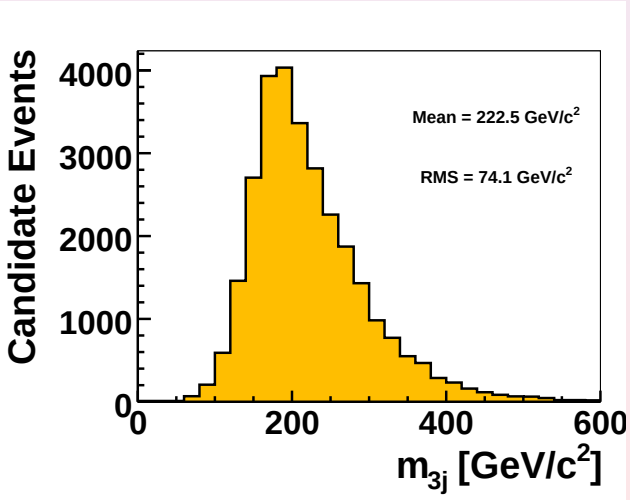
Signal Fraction for different Cut Scenarios

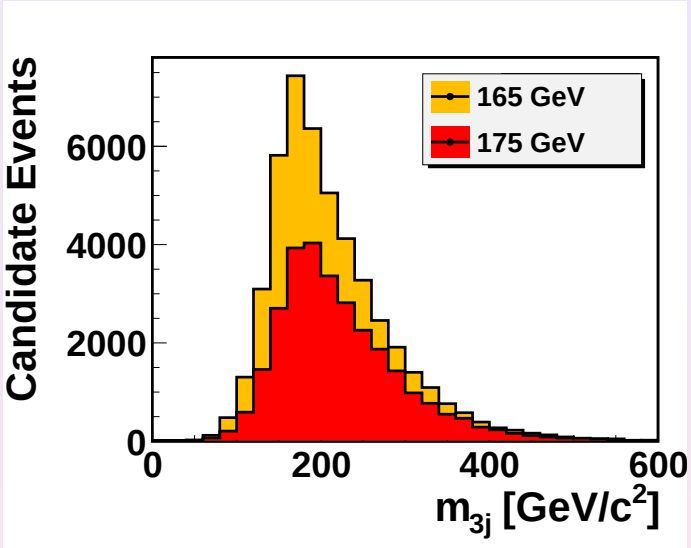
Cut scenario	N_{data}	sig. fraction	S/B	$S/\sqrt{B}$
(a)	2503	0.117	0.13	1.25
(b)	1748	0.547	1.21	8.13
(c)	776	0.756	3.10	15.3

(a): $N_{jets} \geq 4$
(b): $N_{jets} \geq 3$ and require ≥ 1 b-tag
(c): $N_{jets} \geq 4$ and require ≥ 1 b-tag

Invariant mass of the three leading jets

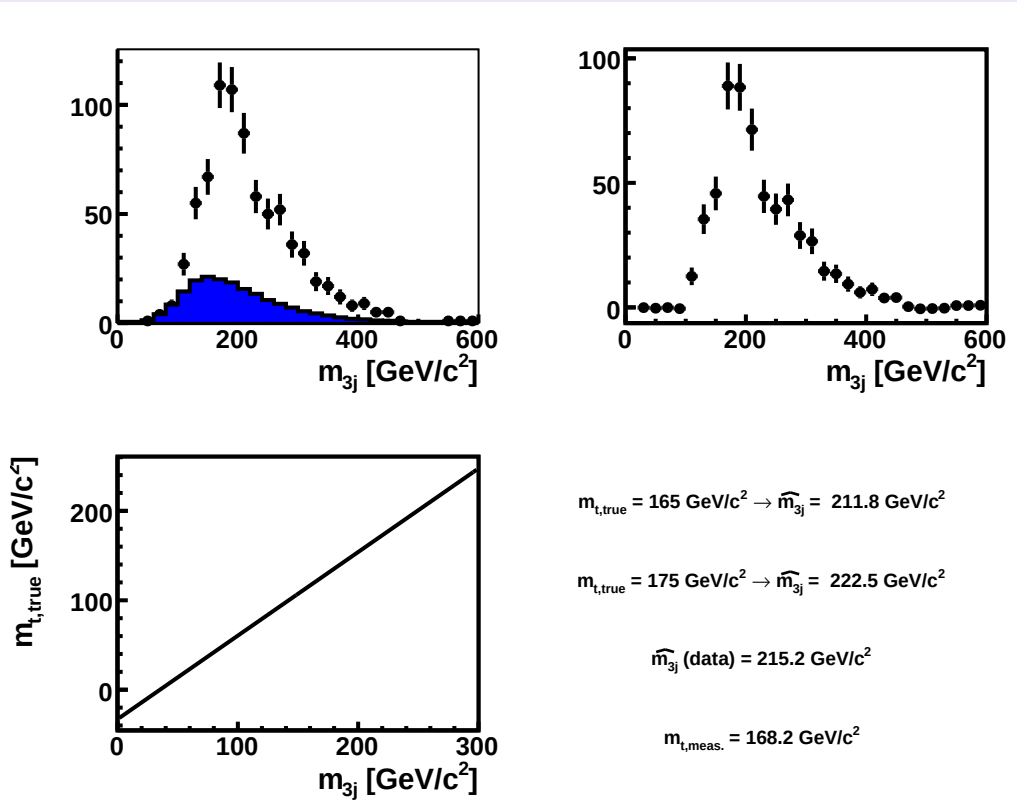






MC top mass	Mean	RMS
165	211.8	72.1
175	222.5	74.1

Background Subtraction



- assume linear dependence between mean of tri-jet mass and the true top mass
- $m_{t,true} = \alpha \cdot m_{3j} + \beta$

Results

our analysis:	$m_{top} \approx 168.2\mathrm{GeV}$
CDF Lepton+Jets (Run1):	$m_{top} = 176.1 \pm 5.1 \pm 5.3\mathrm{GeV}$

Summary

- H_T and (reliable) b-tagging have great discriminating power for top events
- Our templatefit allows rough mass estimation
- Thanks to the tutors for preparing this tutorial ☺