Reconstructing Top-Quark Events in CDF Data

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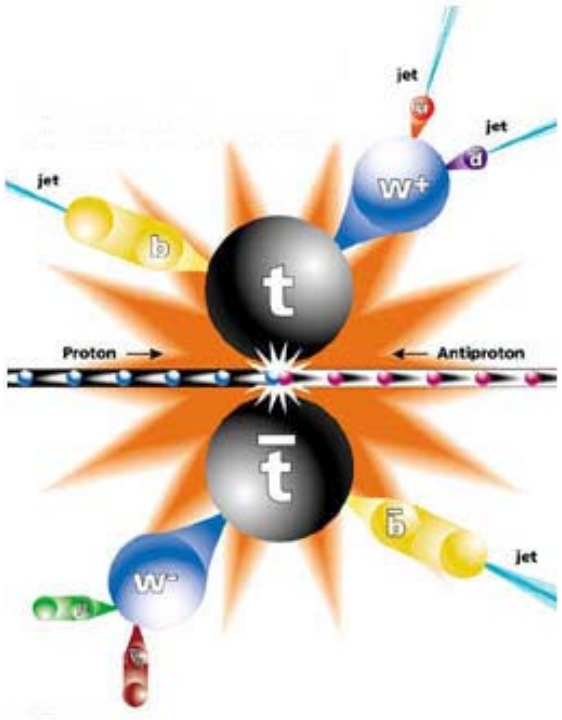
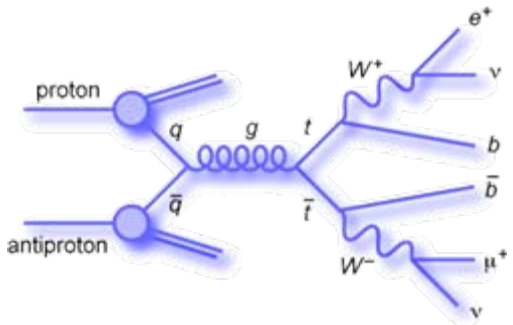


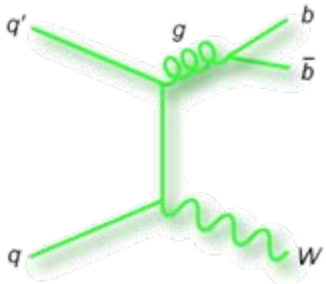
General Remarks

- Aims of this tutorial: Learn how to
  - select top-antitop candidates in W+jets sample.
  - enrich top-antitop events using event shape and b tagging.
  - determine the signal fraction within the selected sample.
  - determine the top-quark mass.
- This tutorial is not about programming, nor a ROOT tutorial.
- It‘s mostly running existing code and understand what it does.
- Take your time to look at the code and understand it.

Data Samples and Processing

- Top-antitop samples:
  - `tt175.root`
  - `tt165.root`
- W + bb_bar sample:
  - `Wbb.root`
- Observed data sample:
  - `data.root`

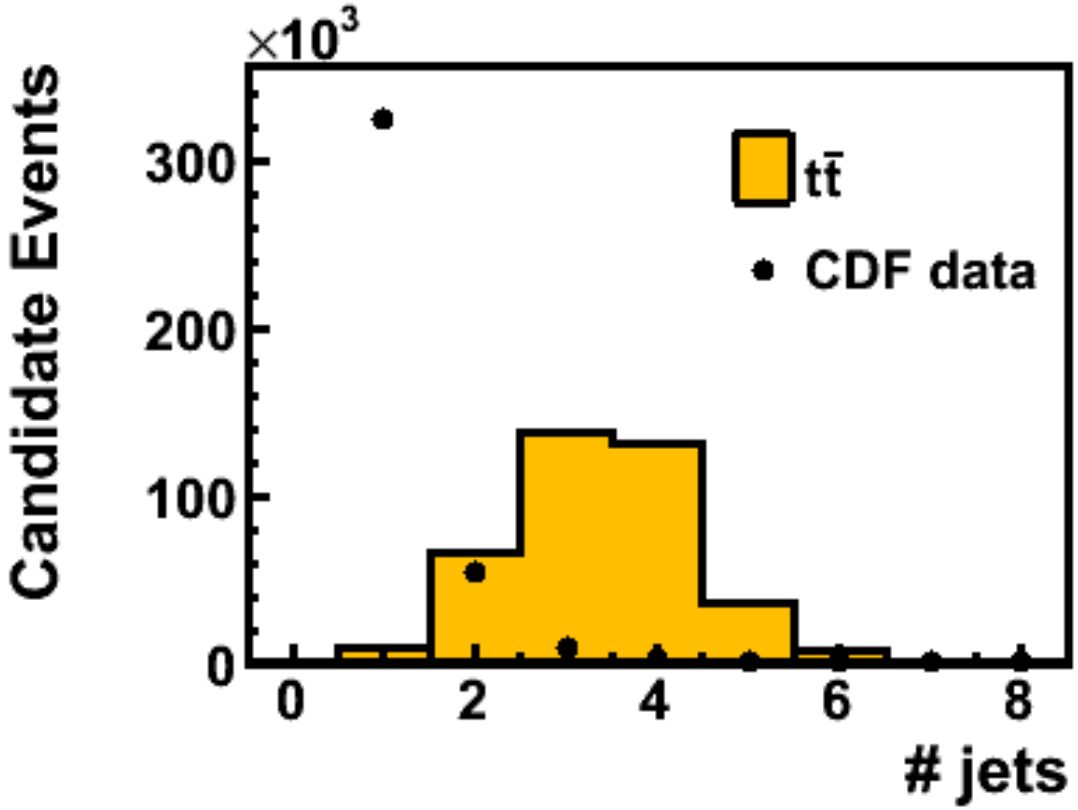




- One compiled program: `runTTbar.exe`, source code `runTTbar.cc`
  - to process the data, select events and produce histograms.
  - After changes in `runTTbar.cc` you need to recompile by calling `make`.
  - Reprocess the samples, for example `./runTTbar.exe tt175`
- One interpreted program to plot histograms: `plotHistos.C`

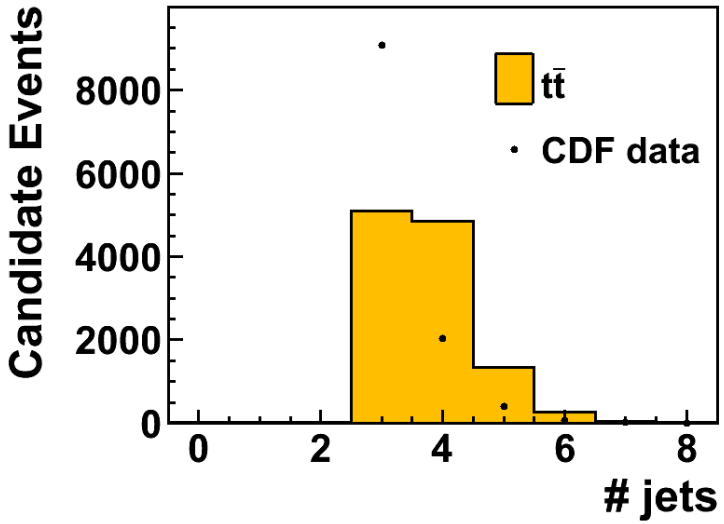
Exercise 1: Number of high-p_T jets

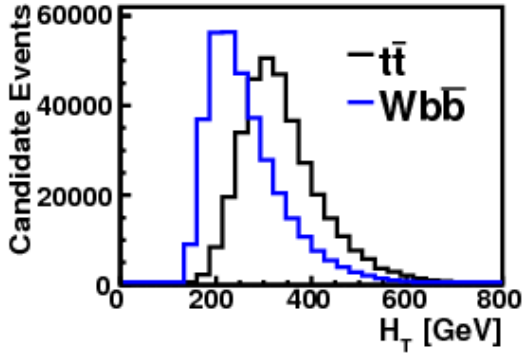
- Aim: Find a useful cut on the number of high-p_T jets.
- What does the discrepancy between top-antitop and the observed data tell you?

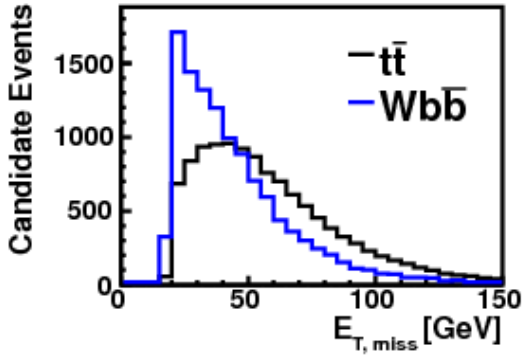


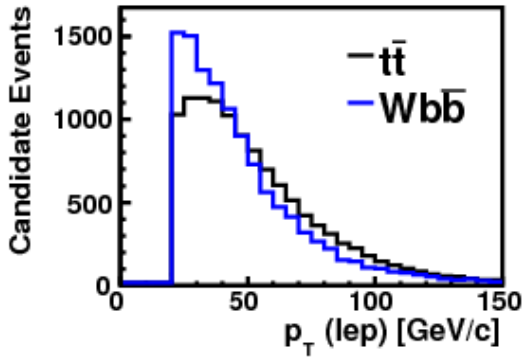
Exercise 2: Study of Event-Shape Variables

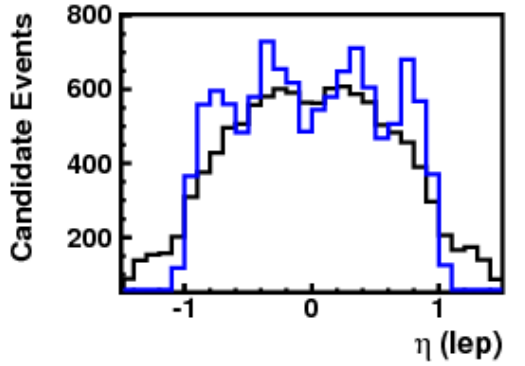
- Aim: Find a discriminat between signal and background.
  - Apply the N_{jet} cut found in exercise 1.
  - Look at four kinematic or event-shape variables.
  - Find one that gives you good discrimination between signal and background.





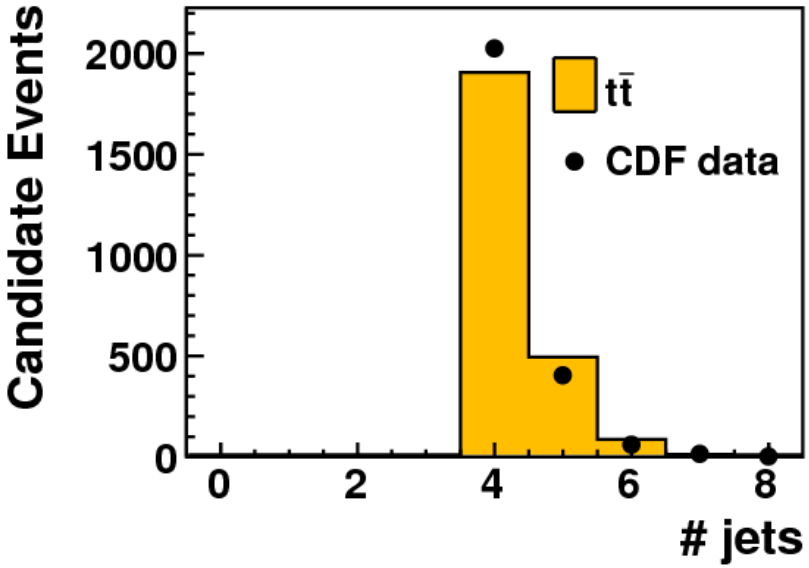


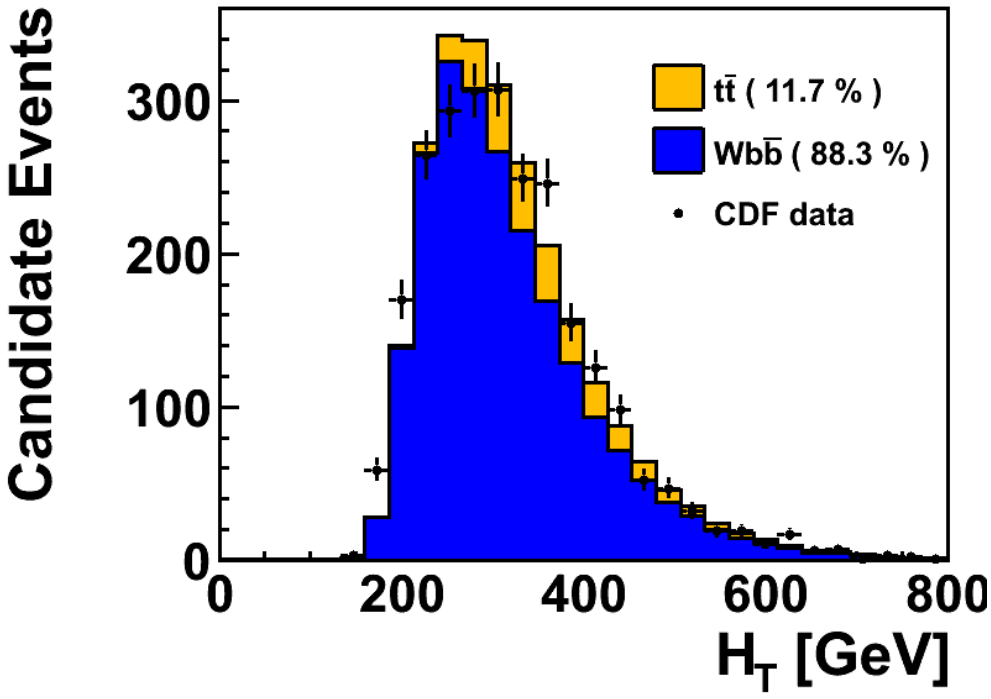




Exercise 3: Top-Antitop Fraction

- Aim:
  Perform a maximum likelihood fit to the discriminant to determine the top-antitop signal fraction in the selected sample of events.

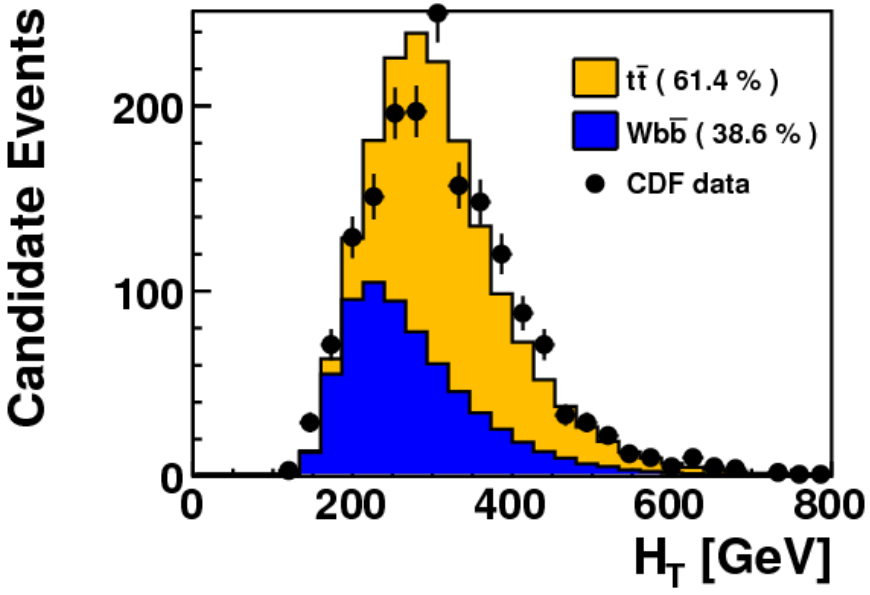




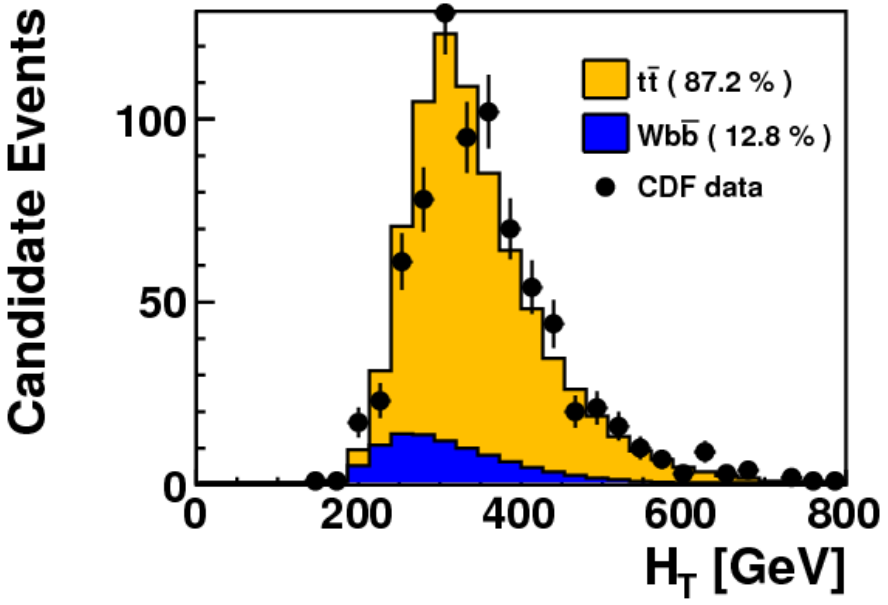
Exercise 4: Improving Signal-to-Background

- Aim:
  Improve the signal-to-background ratio by adding additional cuts.
  - Study several cut scenarios based on the number of jets Njets and a b quark jet requirement.
  - Calculate the quantities signal fraction, S/B, and S/√B for all scenarios.

$(N_{jets} \geq 3)$ && $(N_{btag} \geq 1)$

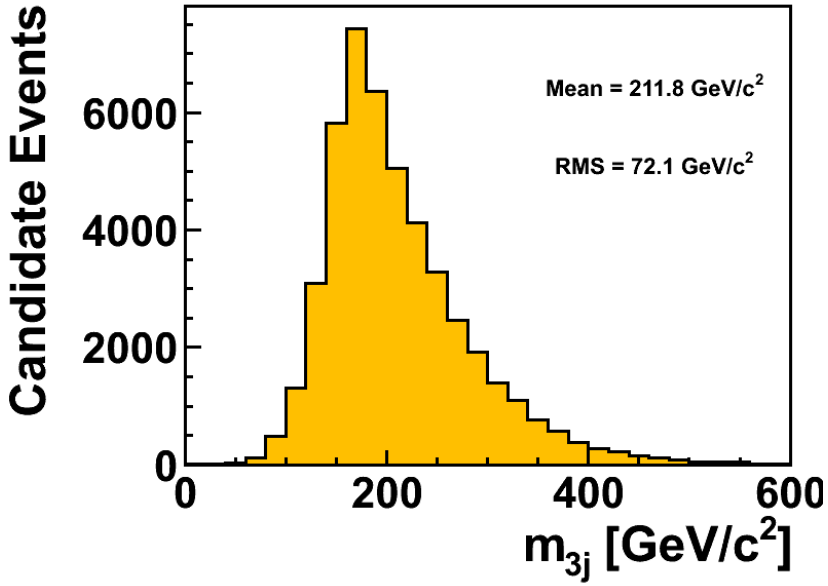


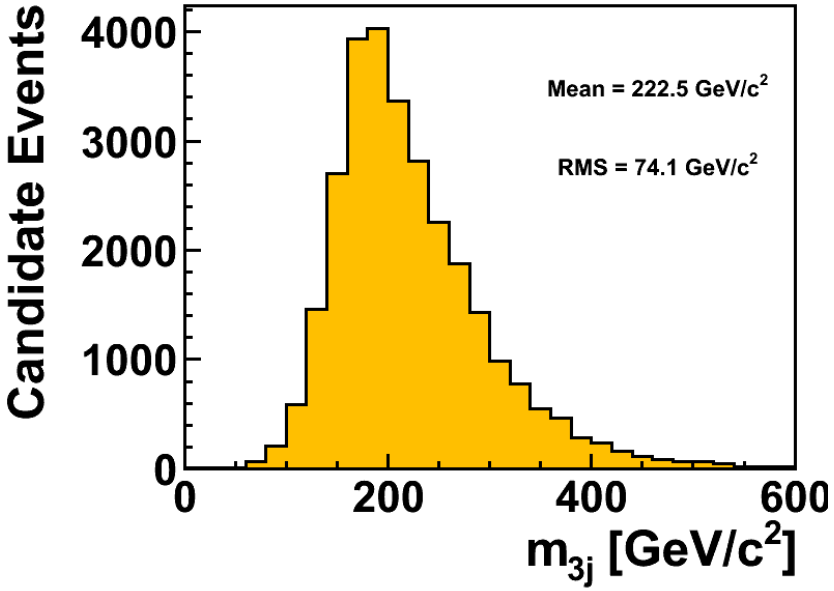
$(N_{jets} \geq 4)$ && $(N_{btag} \geq 1)$



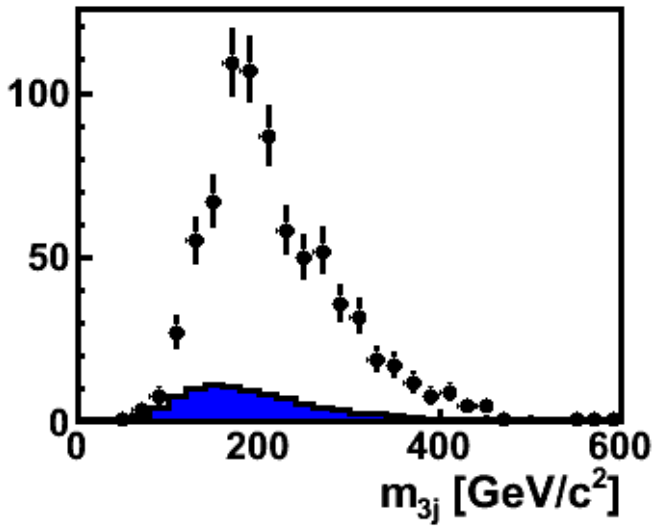
Exercise 5: m_{3j} Distributions

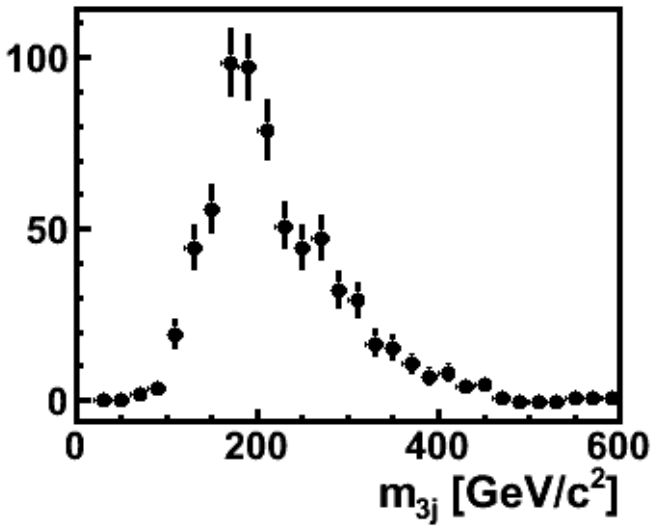
- Aim:
  Construct an observable that is sensitive to the top-quark mass.
  - Calculate the tri-jet mass m_{3j} and determine the corresponding distributions.
  - Determine the mean of the m_{3j} distribution for the top-antitop MC samples of different top-quark mass.

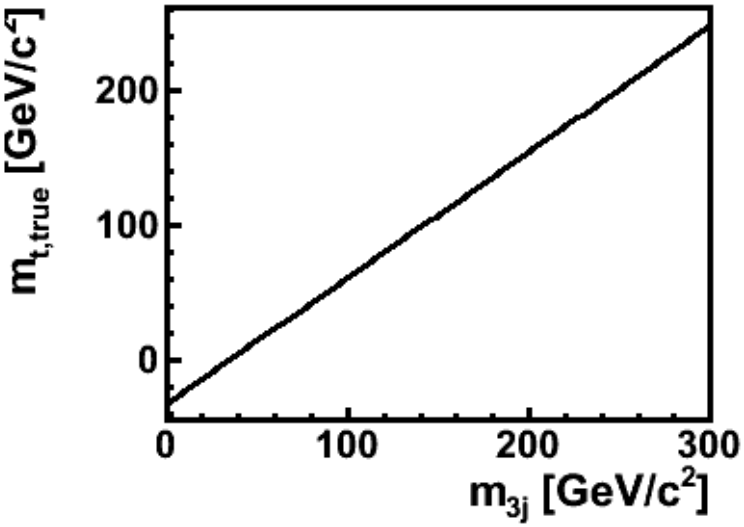




Exercise 6: Measurement of m_t







$m_{t,true}$ = 165 GeV/c^2 → $\widehat{m_{3j}}$ = 211.8 GeV/c^2

$m_{t,true}$ = 175 GeV/c^2 → $\widehat{m_{3j}}$ = 222.5 GeV/c^2

$\widehat{m_{3j}}$ (data) = 221.4 GeV/c^2

$m_{t,meas.}$ = 174.0 GeV/c^2