Effect of Pythia8 tunes on event shapes and $t\bar{t}$ reconstruction for CLICdb studies

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CLICdp WG Analysis Meeting
July 13, 2017

with some comments from
P.Skands and T.Sjostrand

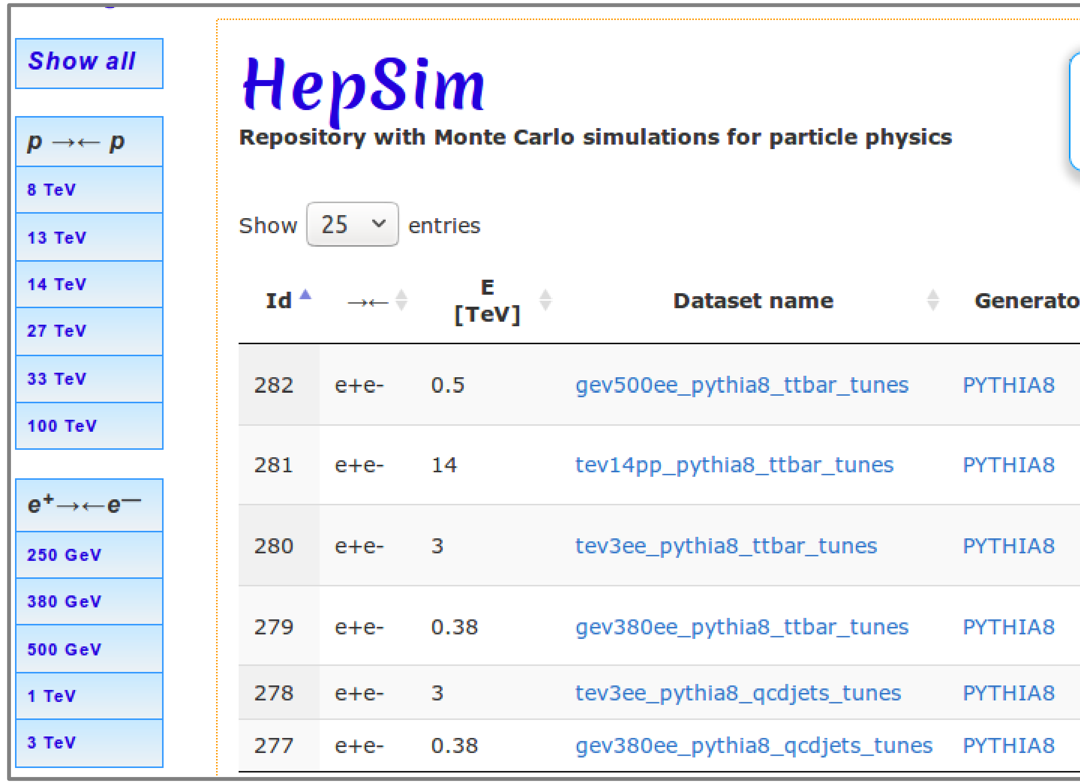
Tunes in Pythia8

- Pythia8 team created a number of “tunes” for e+e-
- Choice of tune to e+e- data, mainly for the hadronization and timelike-showering aspects of PYTHIA. http://home.thep.lu.se/~torbjorn/pythia81html/Tunes.html
  1) option 0 : no values are overwritten during the initial setup **= Option 7**
  2) option 1 : the original PYTHIA 8 parameter set, based on some very old flavour studies (with JETSET around 1990) and a simple tune of alpha_strong to three-jet shapes to the new pT-ordered shower. These were the default values before version 8.125.
  3) option 2 : a tune by M.Montull to the LEP 1 particle composition, as published in the RPP (August 2007). No related (re)tune to event shapes has been performed
  4) option 3 : a tune to a wide selection of LEP1 data by H.Hoeth within the Rivet + Professor framework, both to hadronization and timelike-shower parameters (June 2009). These are the default values starting from version 8.125
  5) option 4 : a tune to LEP data by P.Skands, by hand, both to hadronization and timelike-shower parameters (September 2013). CMW convention for the shower alpha_s scale.
  6) option 5 : first tune to LEP data by N.Fischer (September 2013), based on the default flavour-composition parameters. Input is event shapes (ALEPH and DELPHI), identified particle spectra (ALEPH), multiplicities (PDG), and B hadron fragmentation functions (ALEPH).
  7) option 6 : second tune to LEP data by Nadine Fischer (September 2013). Similar to the first one, but event shapes are weighted up significantly, and multiplicites not included.
  8) option 7 : the Monash 2013 tune by P.Skands [Ska14], to both e^+e^- and pp/pbarp data. **Equivalent to option 0**

See important resource related to tunes in MCPLOT (http://mcplots.cern.ch/)

Generated Pythia8 samples

- Pythia 8.226 (latest)
- e+e- 380 and 3000 GeV CM energy
- Event samples:
  - Z*/gamma → all
    - WeakSingleBoson:ffbar2gmZ=on
    - WeakZ0:gmZmode=0
    - All Z* decays are included
  - Z*/gamma →t $\bar{t}$ (all decays)
  - ISR included (*)
- 2 M events per tune
- Stable particles with ctau>10
- No neutrinos


Show all

p →← p
8 TeV
13 TeV
14 TeV
27 TeV
33 TeV
100 TeV

e+→←e−
250 GeV
380 GeV
500 GeV
1 TeV
3 TeV

HepSim
Repository with Monte Carlo simulations for particle physics

Show 25 entries

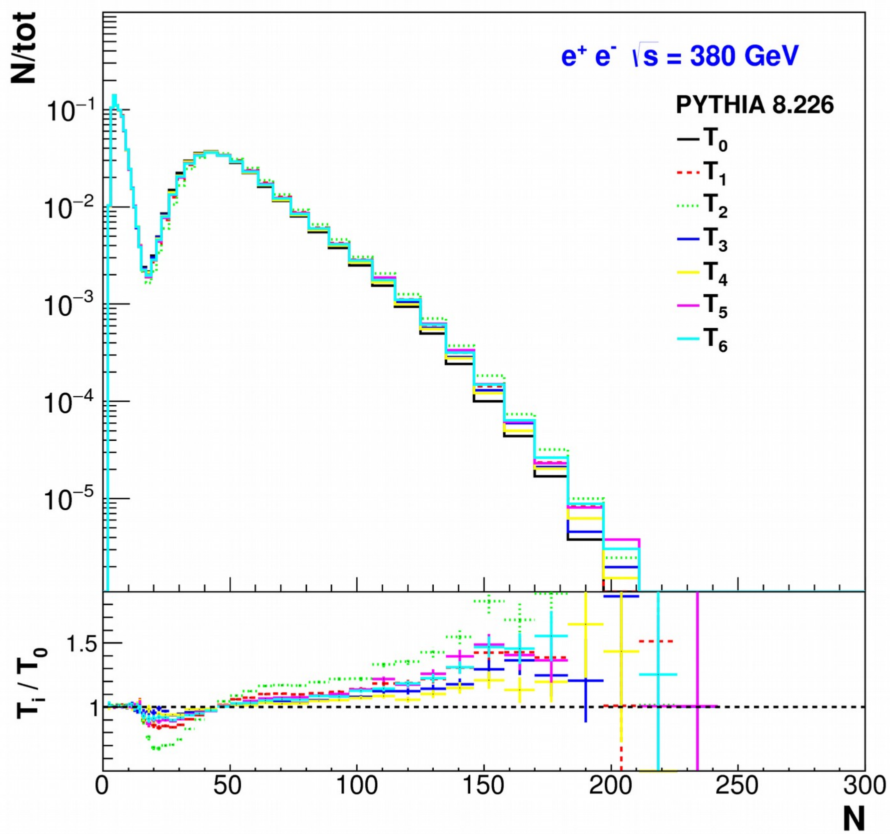
Id	→←	E [TeV]	Dataset name	Generator
282	e+e-	0.5	gev500ee_pythia8_ttbar_tunes	PYTHIA8
281	e+e-	14	tev14pp_pythia8_ttbar_tunes	PYTHIA8
280	e+e-	3	tev3ee_pythia8_ttbar_tunes	PYTHIA8
279	e+e-	0.38	gev380ee_pythia8_ttbar_tunes	PYTHIA8
278	e+e-	3	tev3ee_pythia8_qcdjets_tunes	PYTHIA8
277	e+e-	0.38	gev380ee_pythia8_qcdjets_tunes	PYTHIA8

- Files can be downloaded from HepSim
- Convertible to MCParticles (LCIO files)
- No CLICdb FullSim

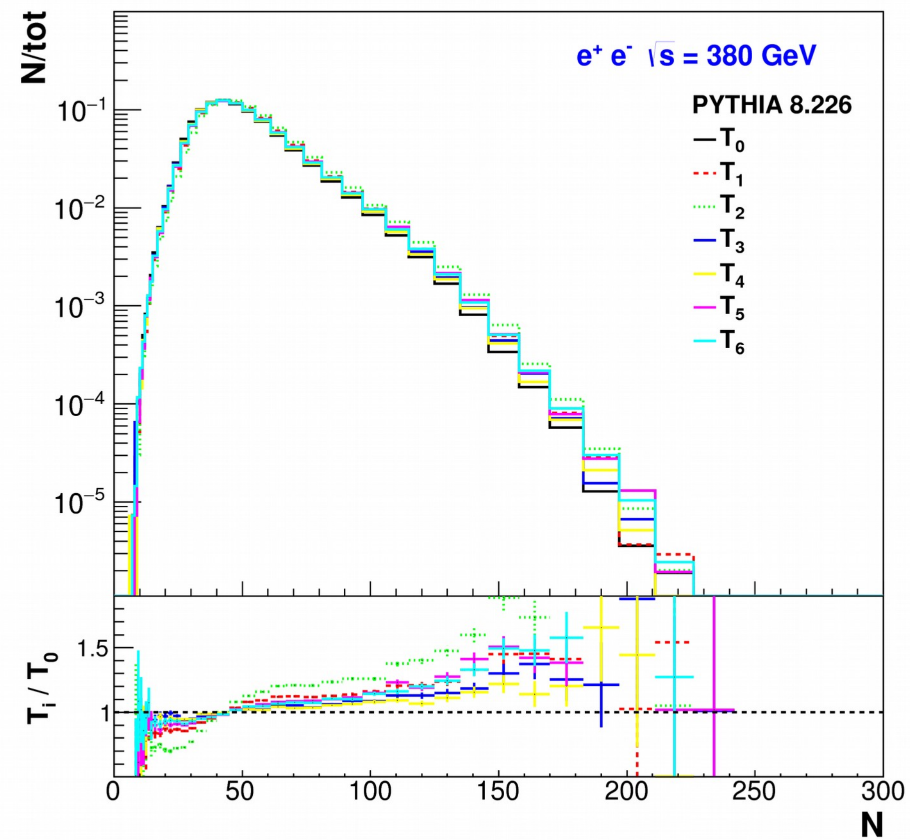
http://atlaswww.hep.anl.gov/hepsim/

380 GeV: Particle multiplicity in $e^+e^- \to Z^*/\gamma$

$e^+ e^- \to Z^*/\gamma \to$ all



$e^+ e^- \to Z^*/\gamma \to q\bar{q}$ (q=u,d,s,c,b)

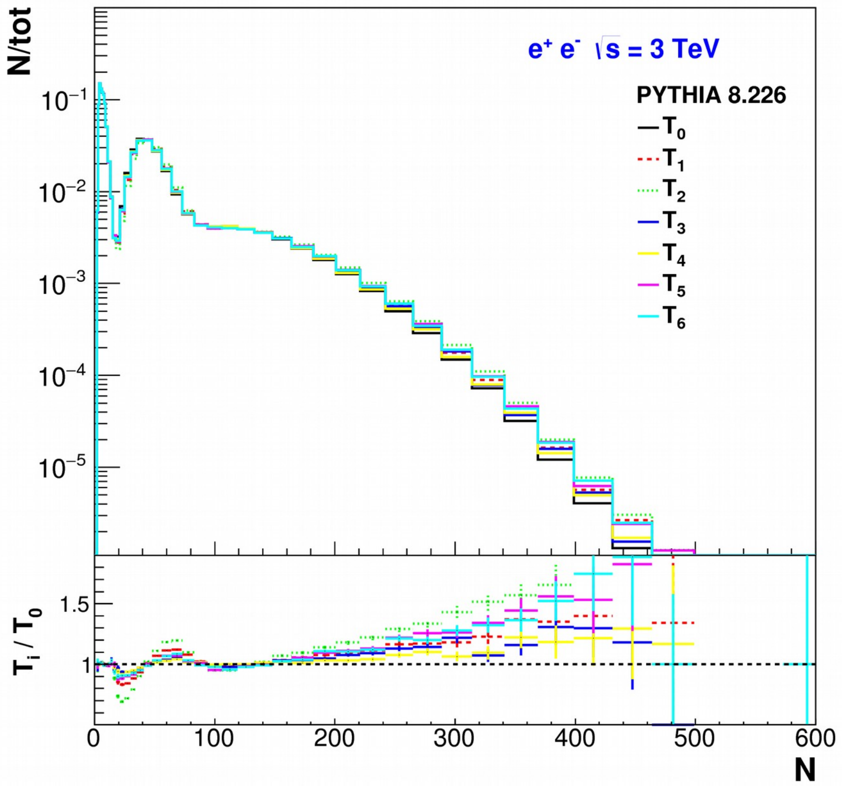


- Charged and neutral particles. No pT and Eta cuts. Plots are normalized to 1
- Fraction of events with N<20 consistent with non-hadronic Z* decays

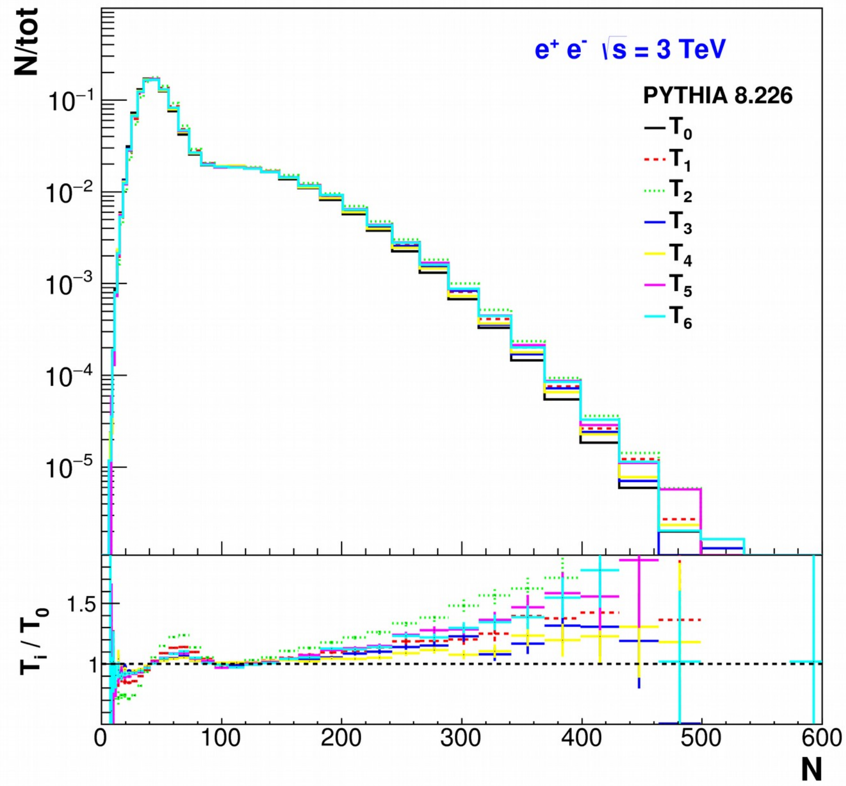
T2 ("Montull") and T5 show largest deviation from the default T0 ("Monash")

3 TeV: Particle multiplicity in $e^+e^- \rightarrow Z^*/\gamma$

$e^+ e^- \rightarrow Z^*/\gamma \rightarrow$ all



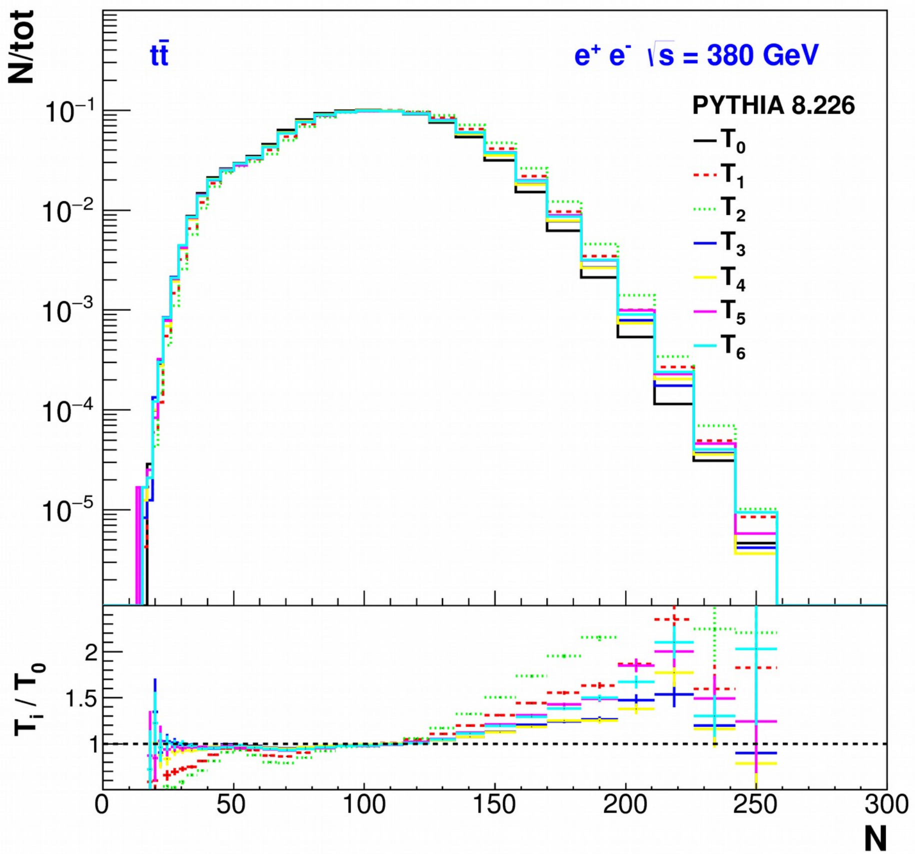
$e^+ e^- \rightarrow Z^*/\gamma \rightarrow q\bar{q}$ (q=u,d,s,c,b)

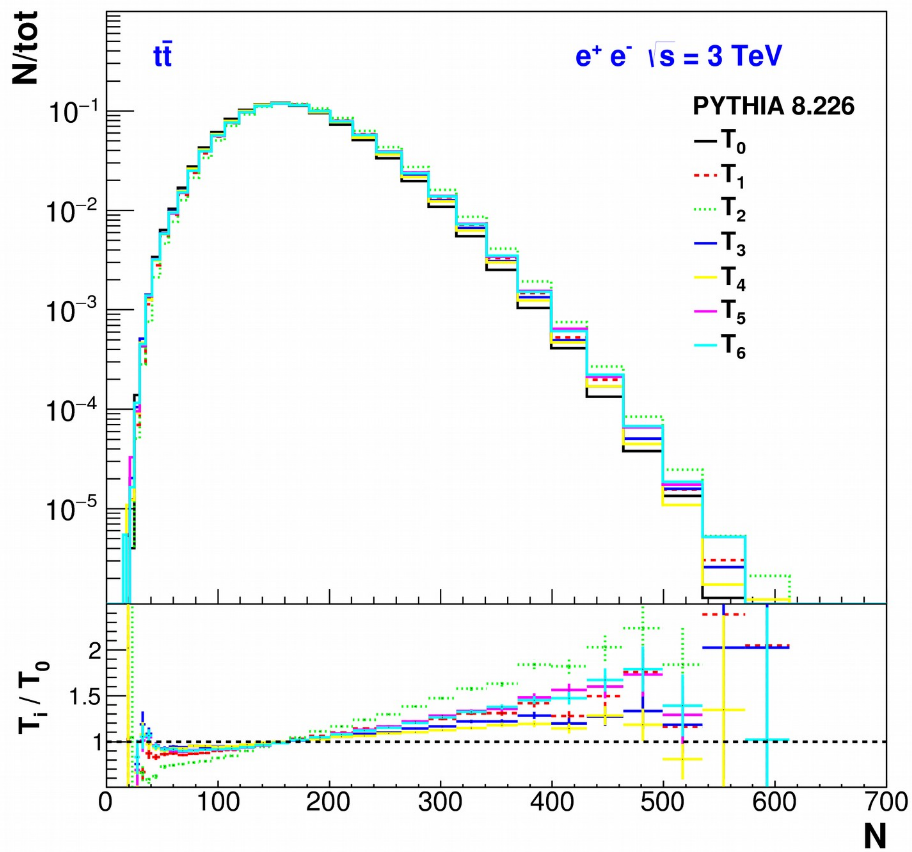


- Charged and neutral particles. No pT and Eta cuts
- Fraction of events with N<20 consistent with non-hadronic Z decays

T2 ("Montull") and T5 show largest deviation from the default T0 ("Monash")

Particle multiplicity in $e^+e^- \rightarrow Z^*/\gamma \rightarrow t\bar{t}$ (all decays)





T2 ("Montull") and T5 show largest deviation from the default T0 ("Monash")

Event shapes

- Thrust: $$T = \max_{\vec{n}_T} \frac{\sum_i |\vec{p}_i . \vec{n}_T|}{\sum_i |\vec{p}_i|}$$

In the limit of two narrow back-to-back jets T→1, while its minimum value of 1/2 corresponds to events with a uniform distribution of momentum flow in all directions.

- Thrust Major $$T_M = \max_{\vec{n}_M} \frac{\sum_i |\vec{p}_i . \vec{n}_M|}{\sum_i |\vec{p}_i|} ,$$ $$\vec{n}_M . \vec{n}_T = 0$$

- Thrust Minor $$T_m = \frac{\sum_i |\vec{p}_i . \vec{n}_m|}{\sum_i |\vec{p}_i|} ,$$ $$\vec{n}_m = \vec{n}_T \times \vec{n}_M$$

- Oblateness=Major-Minor

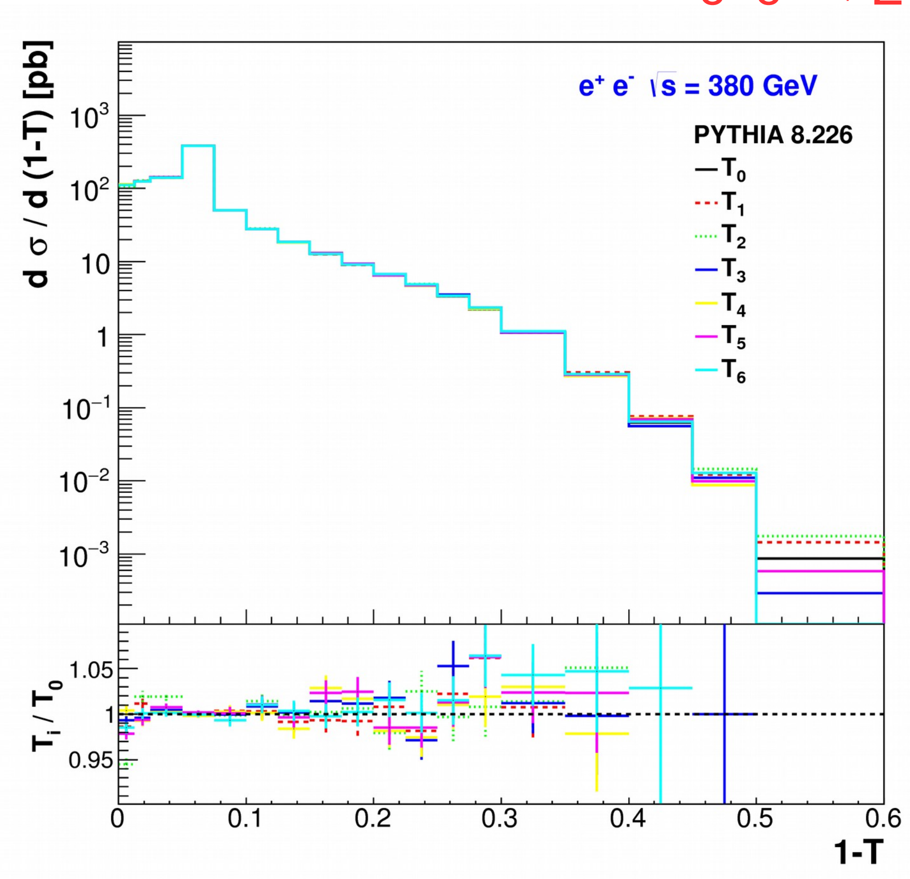
Recent overview: M.Dasgupta, G.Salam
https://arxiv.org/pdf/hep-ph/0312283.pdf

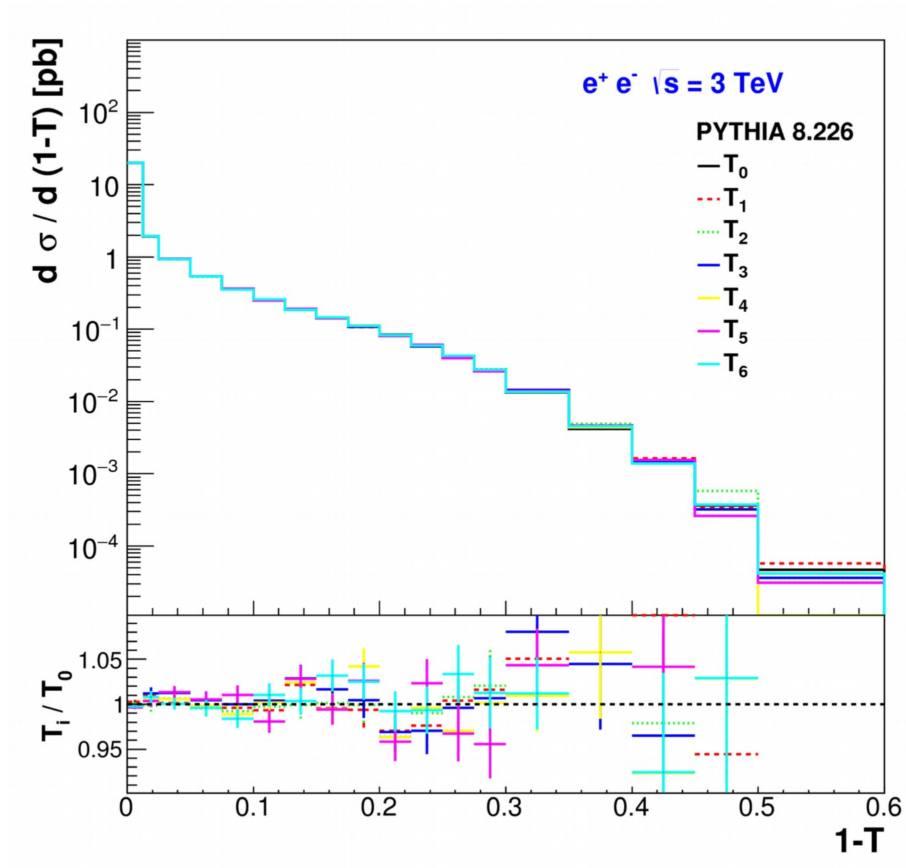
- ThrustReconstruction package from: /cvmfs/clicdp.cern.ch/iLCSoft/builds/2017-05-15/x86_64-slc6-gcc62-opt/MarlinReco/HEAD/Analysis/EventShapes/

- “Jetset” type event shapes

380 GeV: Thrust values

$e^+ e^- \rightarrow Z^*/\gamma \rightarrow q\bar{q}$ (q=u,d,s,c,b)

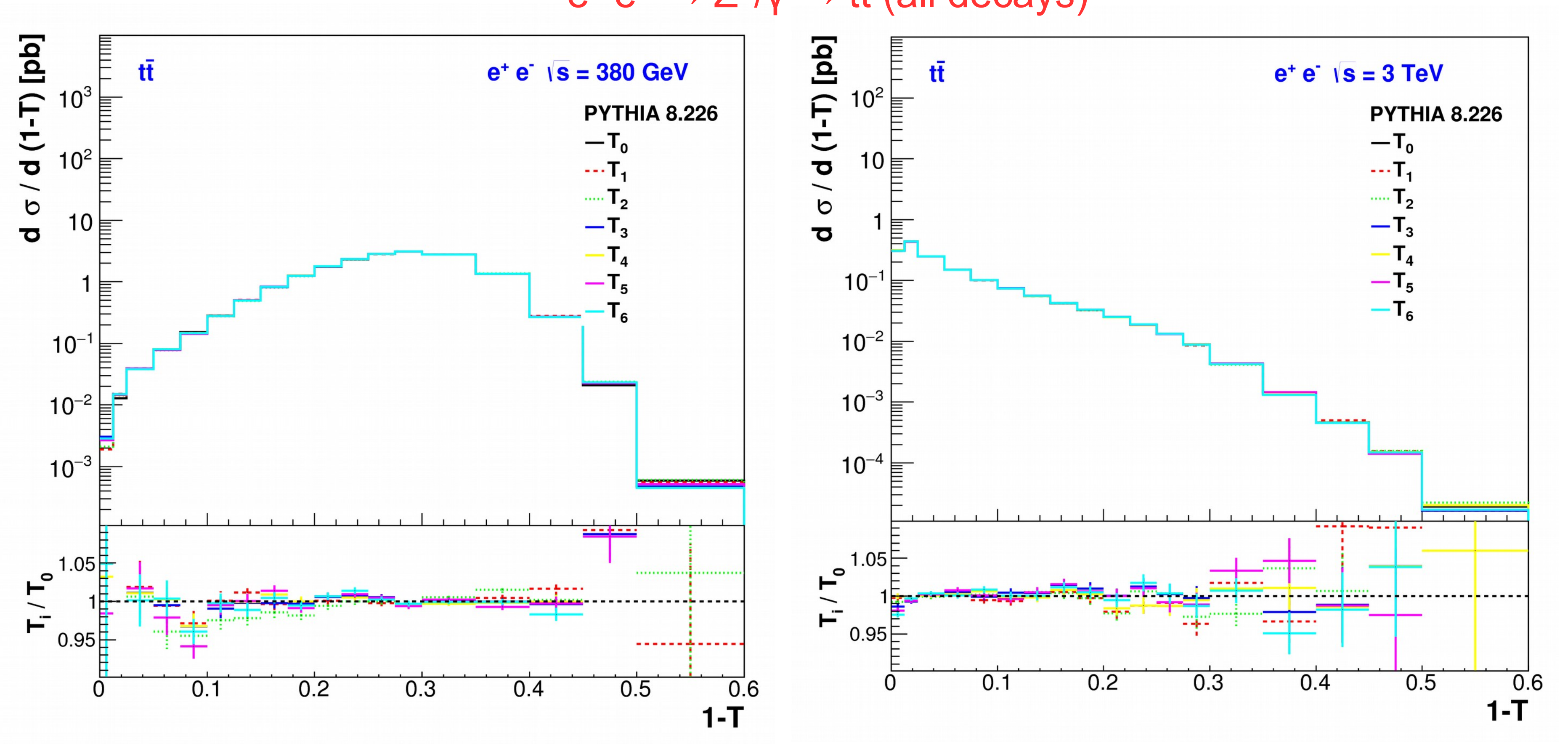




- More “dijet-like” events for 3 TeV (1-T ~ 0) compared to 380 GeV
- T2 (“Montull”) tune shows largest deviation for small 1-T
- Difficult to observe systematic trends for large value of 1-T

Thrust values in top-quark events

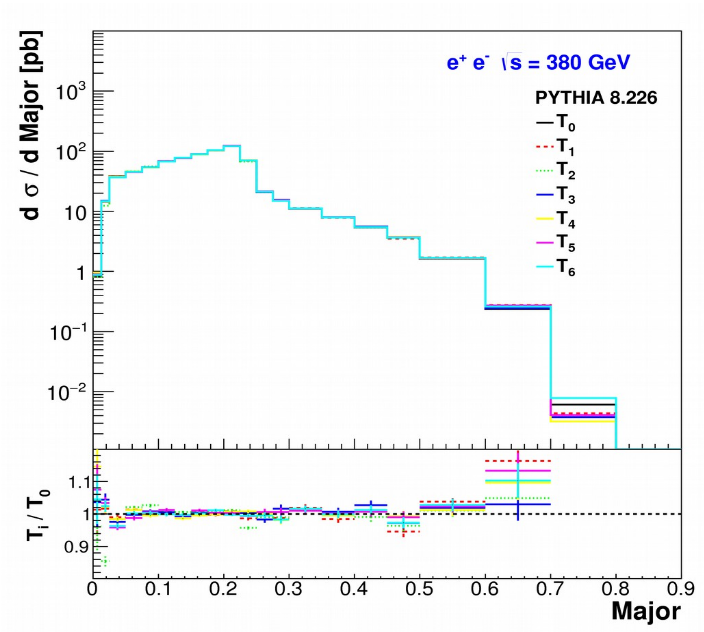
$e^+ e^- \rightarrow Z^*/\gamma \rightarrow t\bar{t}$ (all decays)

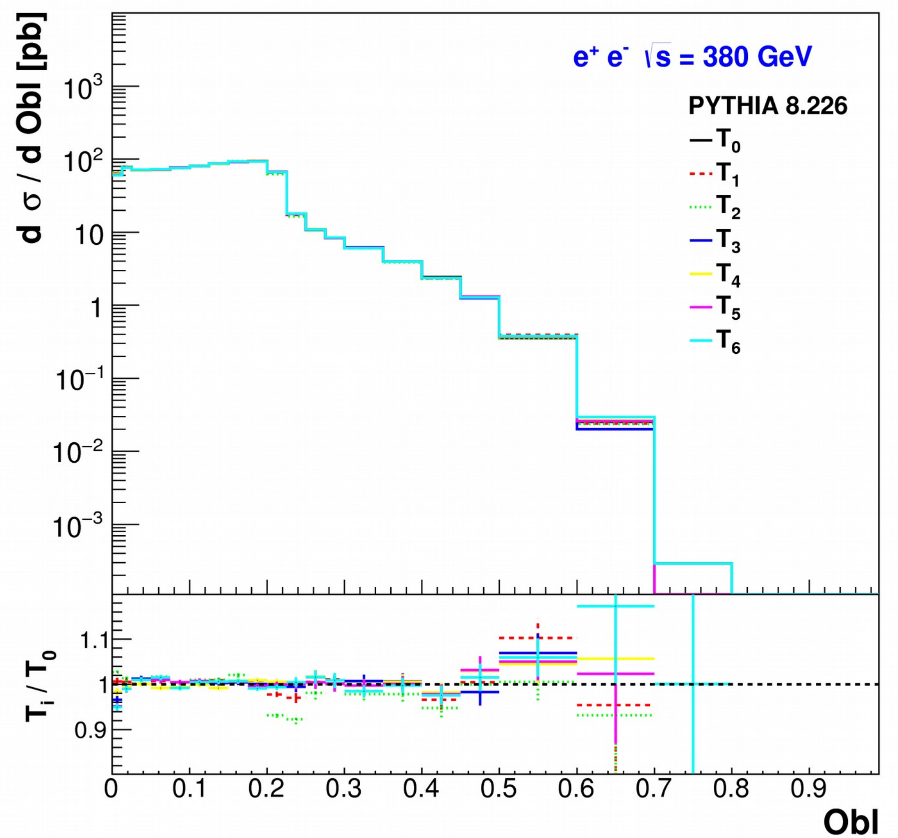


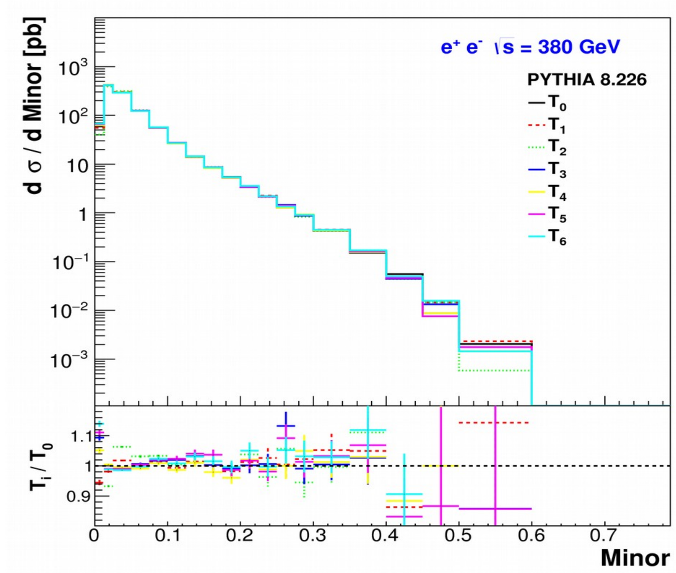
- Significant difference compared to light-flavor QCD jets
- More "dijet-like" events for 3 TeV (1-T ~ 0) compared to 380 GeV
- Difficult to observe systematic trends for different tunes

380 GeV: Major, Minor, Oblateness

$e^+ e^- \rightarrow Z^*/\gamma \rightarrow q\bar{q}$ (q=u,d,s,c,b)





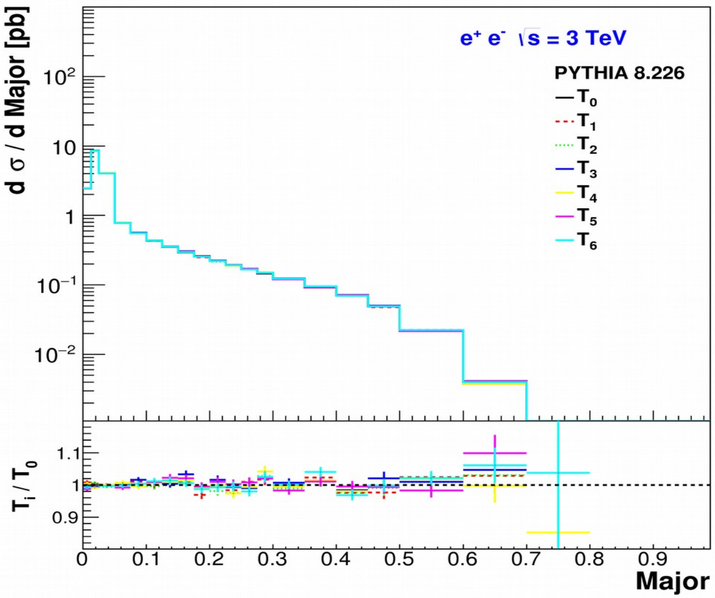


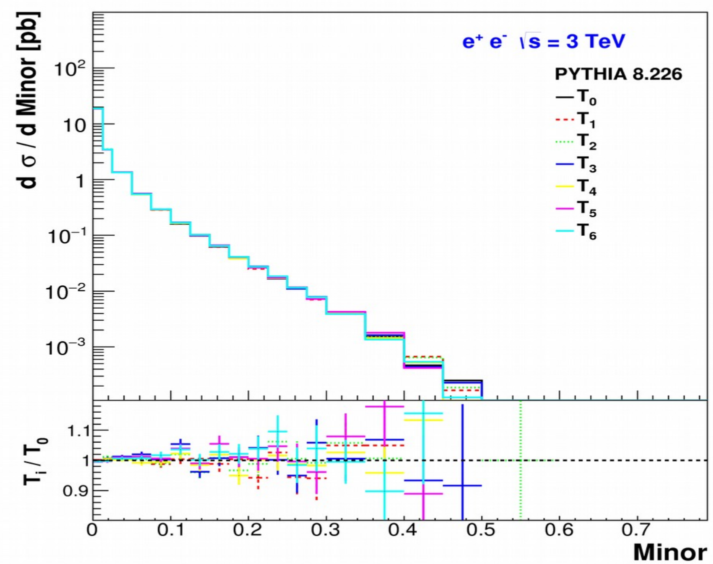
- T2 (“Montull”) tune shows largest deviation for small values of Minor and Major (<10%)
- Difficult to observe systematic trends for different tunes
- See backup slides for top events

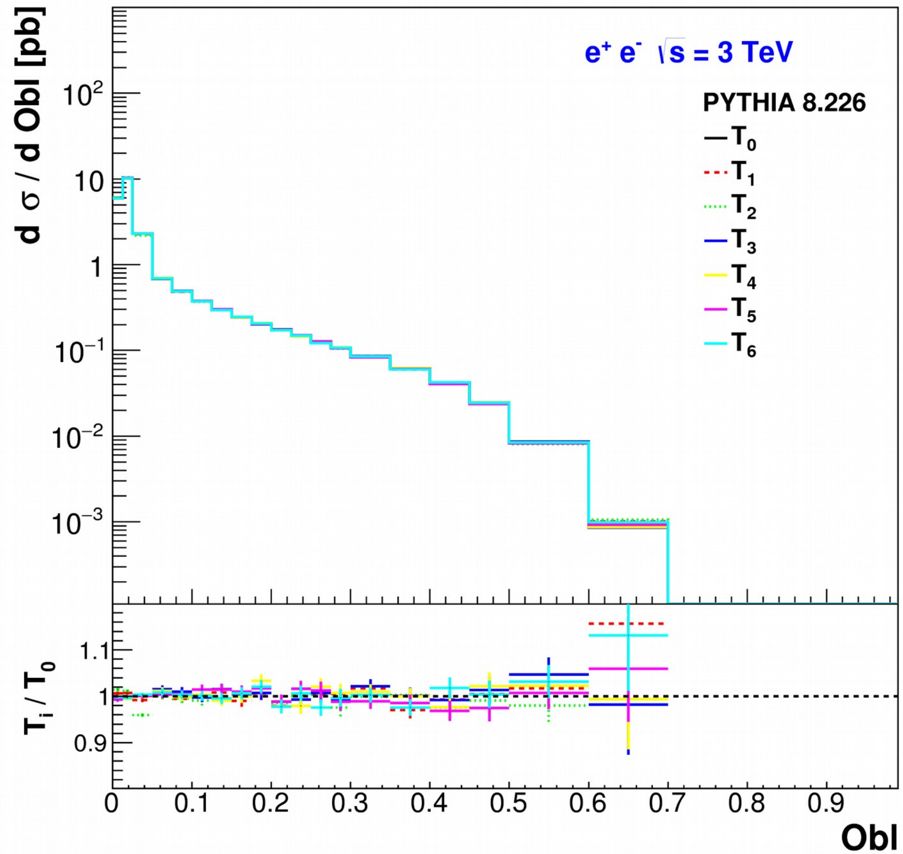
ANL)

3 TeV: Major, Minor, Oblateness

$e^+ e^- \rightarrow Z^*/\gamma \rightarrow q\bar{q}$ (q=u,d,s,c,b)





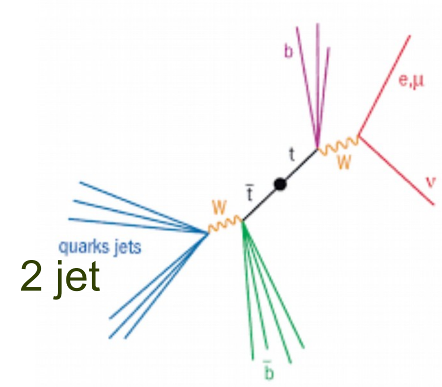


- T2 (“Montull”) tune shows largest deviation for small values of Minor and Major (<10%)
- Difficult to observe systematic trends for different tunes
- See backup slides for top events

Top reconstruction in semileptonic decays

380 GeV: Resolved case. Semileptonic decay

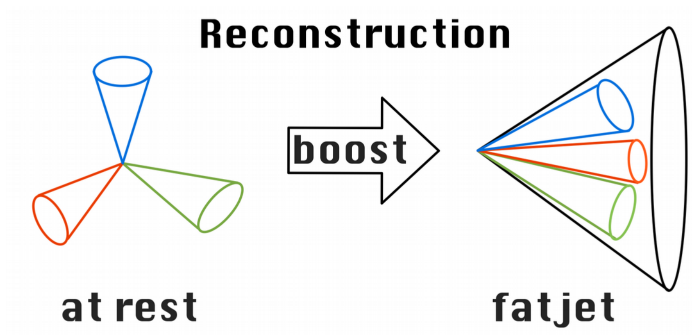
- Identify and remove leptons from W decays
- Four kT jets with R=1.0 in exclusive mode using FastJet
- Input for jets: all final state particles (charged+neutral) but neutrino
- Identify b-jet using a cone algorithm with dR=R/2, matching b-quark with kT jet
- Identify 2 light-flavor jets for Mjj
- Constrain M(W)-20 GeV < Mjj < M(W)+20 GeV
- Calculate 3-jet mass



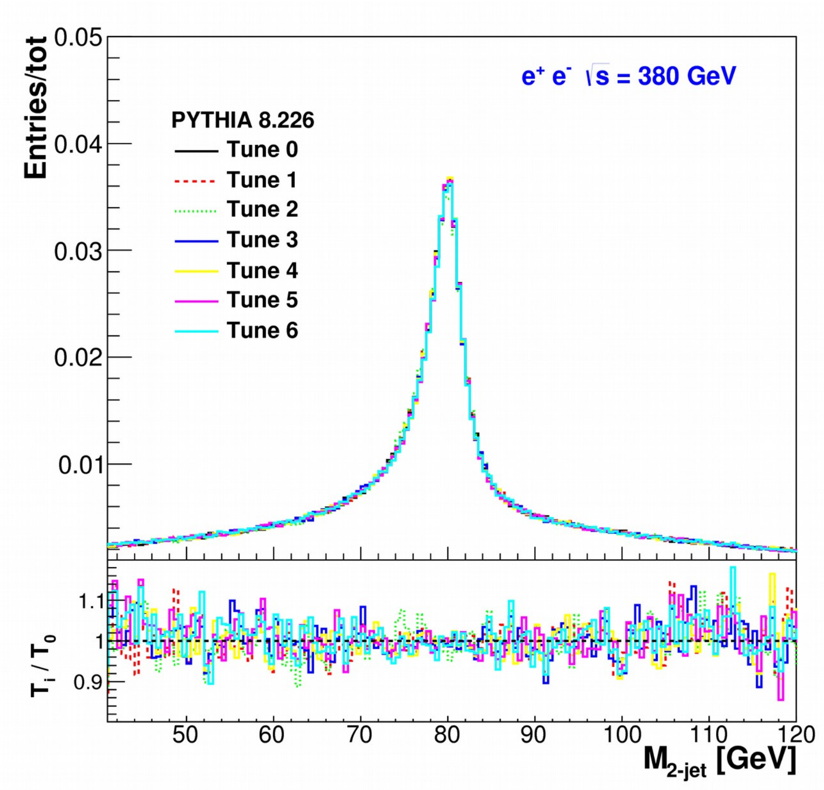
3 jet

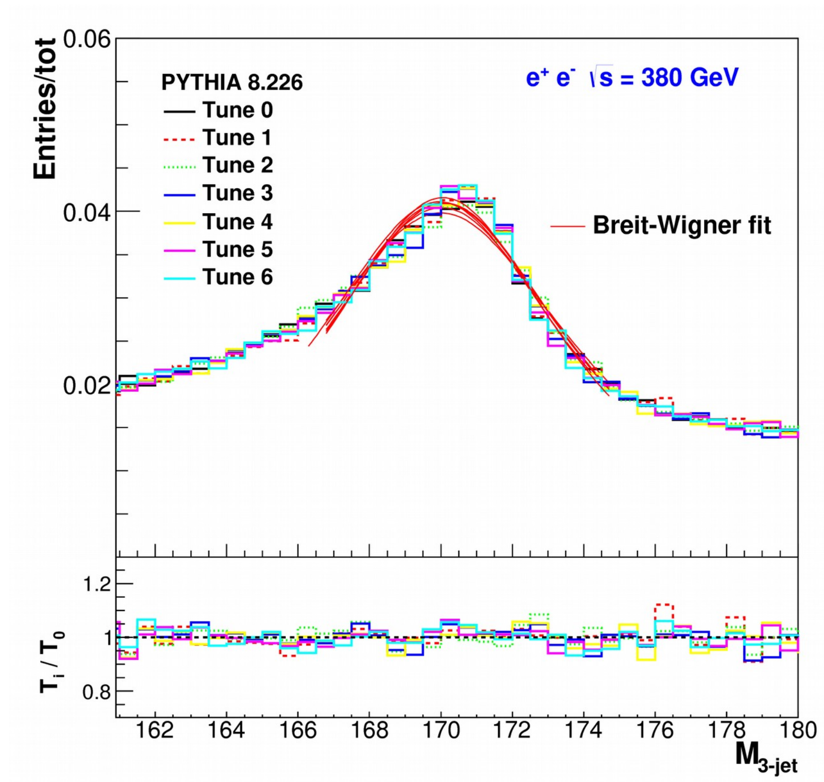
3 TeV: Boosted top reconstruction

- Remove leptons from W
- Force 2 jets using exclusive kT jets with R=1.2
- Calculate jet mass for leading jet



Resolved top reconstruction: 380 GeV CM energy



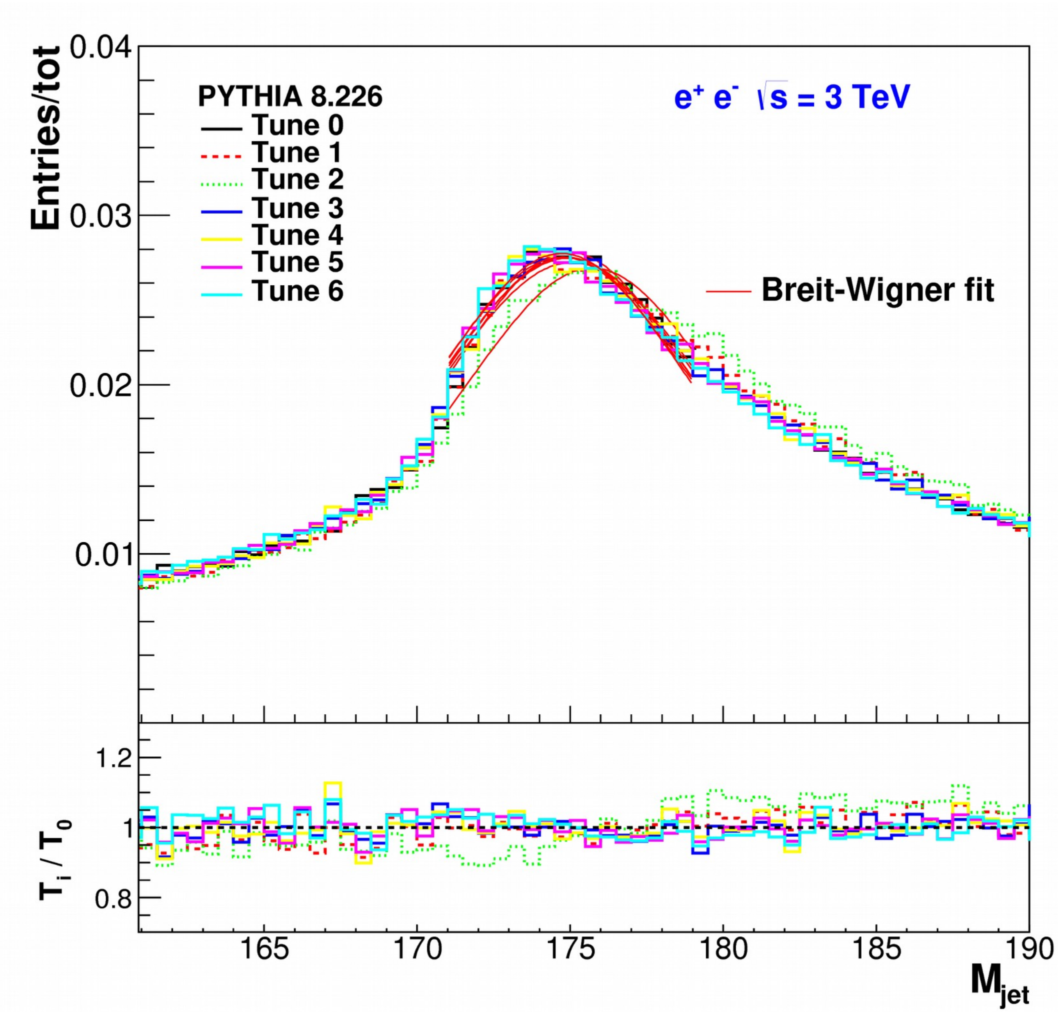


Peak positions of BW fits

tune=0 peak=170.02 GeV
tune=1 peak=170.04 GeV
tune=2 peak=170.00 GeV
tune=3 peak=170.07 GeV
tune=4 peak=170.09 GeV
tune=5 peak=169.95 GeV
tune=6 peak=170.05 GeV

Max shift from 7 tunes: ± 80 MeV

Boosted top reconstruction: 3 TeV CM energy



tune=0 peak=174.98 GeV
tune=1 peak=175.05 GeV
tune=2 peak=175.71 GeV
tune=3 peak=174.87 GeV
tune=4 peak=174.92 GeV
tune=5 peak=174.73 GeV
tune=6 peak=174.71 GeV

min shift: = 280 MeV
max shift: = 710 MeV

Shift for T2 correlates with the corresponding increase in particle multiplicity (see before)

Tune 2: - a tune by M.Montull to the LEP 1 particle composition, as published in the RPP (August 2007). No related (re)tune to event shapes has been performed

Note: "resolved" Mjjj reconstruction for the 3 TeV case has too small statistics to check the tunes

Summary

- Effect of Pythia8 tunes on dijets QCD and $t\bar{t}$ has been studied without detector simulation. Differences from the default “Monash” were studied

- Tune 2 (“Monfull”) shows significant change in particle multiplicity

- Some effect (<10%) was found for standard event shapes (Thrust, Major, Minor, Oblateness)

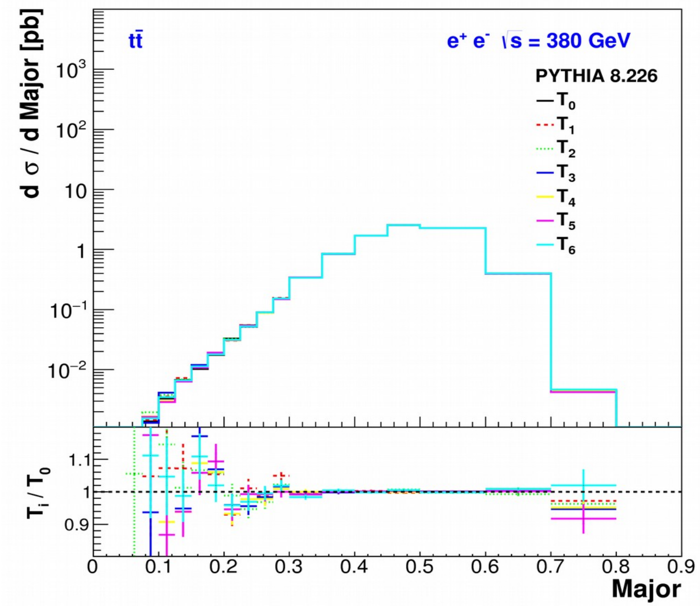
- Effect from the tunes on resolved top-mass reconstruction is < 80 MeV

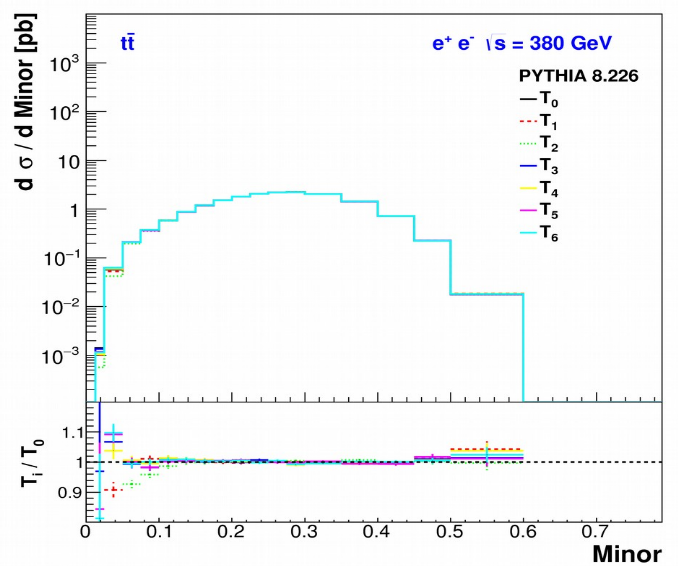
- Significant effect on jet mass was observed in the boosted regime (3 TeV)
  - 700 MeV shift was observed for the top mass calculated from jet masses
  - T2 (“Montull”) shows the largest effect (correlates with particle multiplicity)

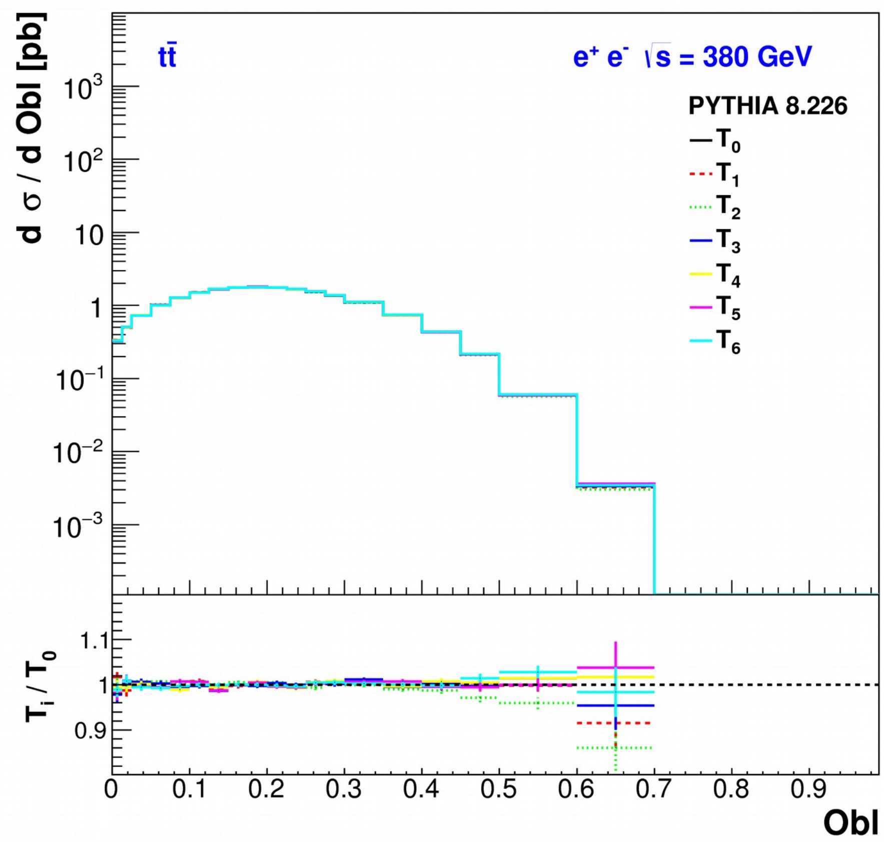
- Future updates of these results will include Pythia8 setting without ISR and full CLICdb reconstruction

Backup

380 GeV: Major, Minor, Oblateness for top events

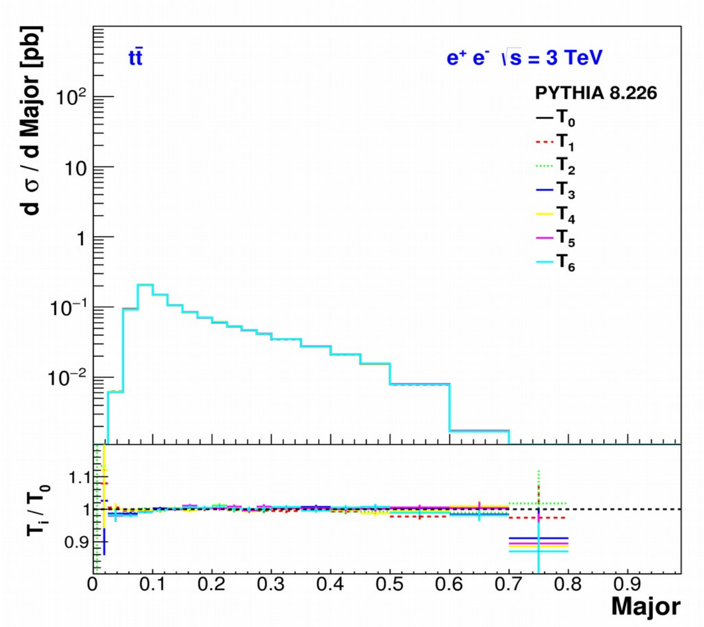


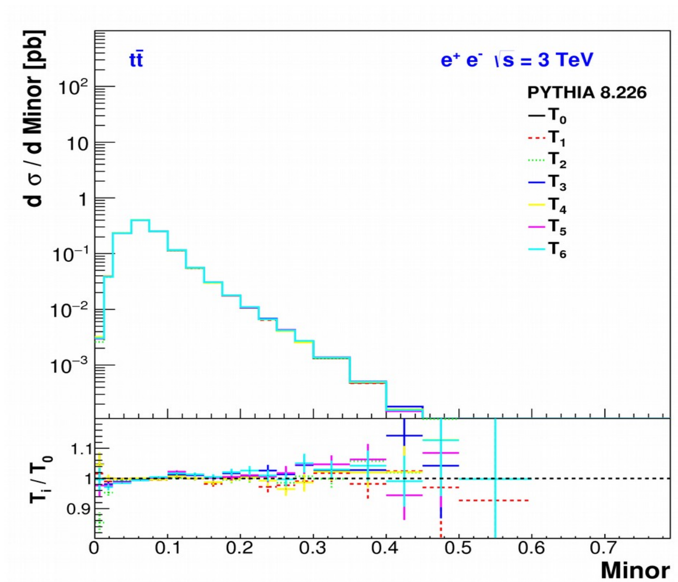


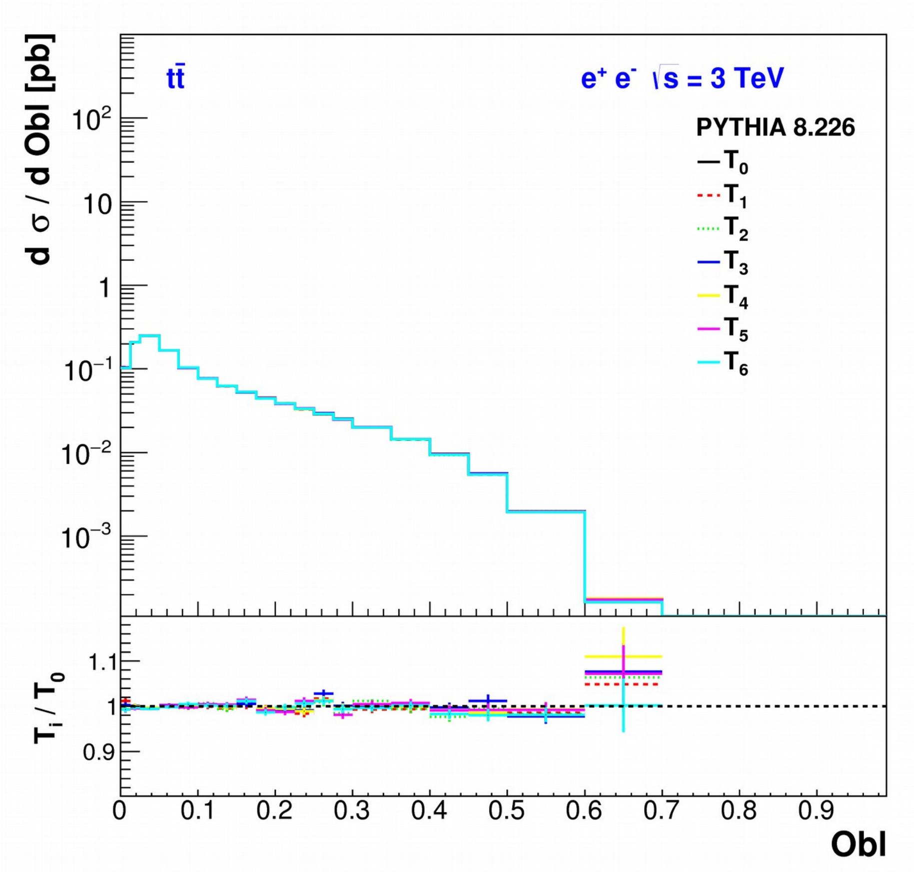


- Difficult to observe systematic trends for different tunes

3 TeV: Major, Minor, Oblateness for top events







- Difficult to observe systematic trends for different tunes