

Reconstruction of $t\bar{t}$ in semi-leptonic and fully-hadronic decay modes at 380 GeV

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(with contributions from P.Roloff, M.Demarteau, A.Sailer)

CLICdp WG Analysis Meeting
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Generated samples

- WHIZARD V1.95
- $m(h) = 12 \text{ TeV}$
- $\alpha_s = 1e-6$
- "l" = mu, tau
- "v" = nu_e, nu_mu, nu_tau
- "y" = d, s, b
- "x" = u, c

Type	ProdID	Events planned	Events produced	σ [fb]	Comments
ee -> yyveev	4517	10000	10500	5.1	
ee -> yyveyx	4523	30000	32000	29.7	
ee -> yyxyev	4535	30000	32000	29.7	
ee -> yyuyyc	4541	40000	41500	41.8	
ee -> yycyyu	4544	40000	45000	41.8	
ee -> dduyyu	4547	40000	66000	37.6	
ee -> ssussu	4550	10000	9500	0.0064	
ee -> ssubbu	4553	10000	10000	0.12	
ee -> bbubbu	4556	10000	10000	0.0058	
ee -> ddcyyc	4559	10000	15500	0.38	
ee -> sscssc	4562	10000	10000	0.22	
ee -> sscbbc	4565	40000	39500	36.9	
ee -> bbcbbc	4568	10000	10000	0.0059	
ee -> yyvelv	4571	10000	10000	10.1	
ee -> yyvlev	4574	10000	10000	10.1	
ee -> yyvllv	4577	20000	19500	20.2	
ee -> yyvlyx	4580	60000	67000	59.3	
ee -> yyxylv	4583	60000	66000	59.3	

- Subsamples scaled to the same luminosity and then added
- CLIC_ILD, 350 GeV luminosity spectrum scaled to 380 GeV
- Signal sample (6-fermion production compatible with ttbar) at 380 GeV assuming unpolarised beams

created by P.Roloff

<https://twiki.cern.ch/twiki/bin/view/CLIC/MonteCarloSamplesForTopPhysics>

Top reconstruction in semileptonic decays

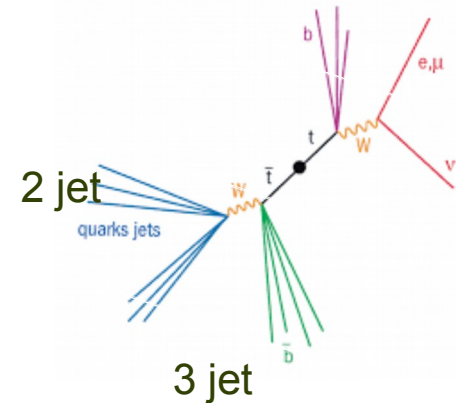
380 GeV: Resolved case. Semileptonic decay

- Use LooseSelectedPandoraPFANewPFOs
- $p_T(\text{lepton}) > 10$ GeV (muon or electron from PFO)
- Missing $p_T > 10$ GeV
- Four kT jets with $R=1.3$ in exclusive mode
 - using FastJet in kT mode
 - Input are all PFOs but high- p_T lepton
- Jet $p_T(\text{jet}) > 10$ GeV and $|y(\text{jet})| < 2.1$
- Use b-tagging cheating: Identify b-jets using a cone algorithm with $dR=0.3$, matching b-quark with kT jet
 - will be updated soon with realistic algorithm
- Identify 2 light-flavor jets for M_{jj}
- Constrain $|M_{jj} - M(W)| < 20$ GeV
- Calculate 3-jet mass using W candidates

Input (1-lepton == e,mu,tau) 1.1 ab⁻¹:

- [yyvlyx_o/ILD/DST/00004580](#)
- [yyxylv_o/ILD/DST/00004583](#)
- [yyveyx_o/ILD/DST/00004523](#)
- [yyxyev_o/ILD/DST/00004535](#)

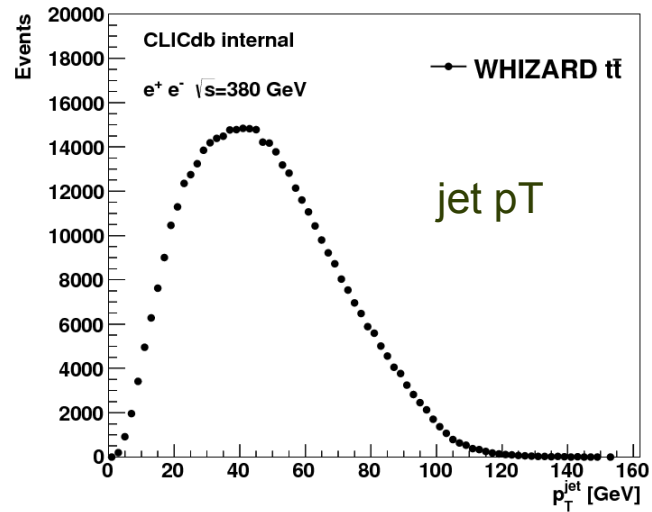
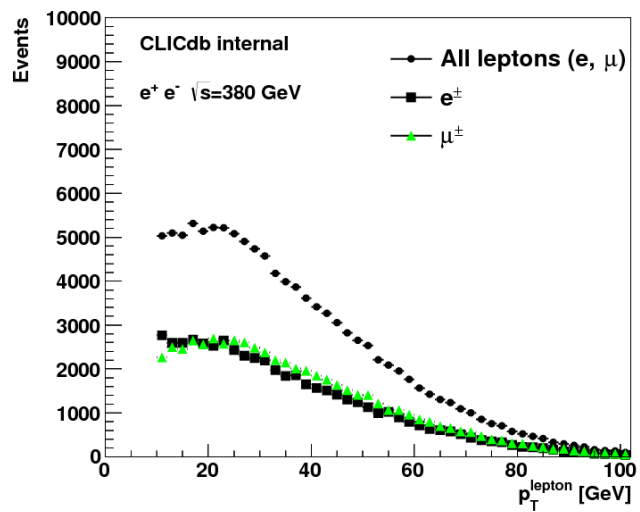
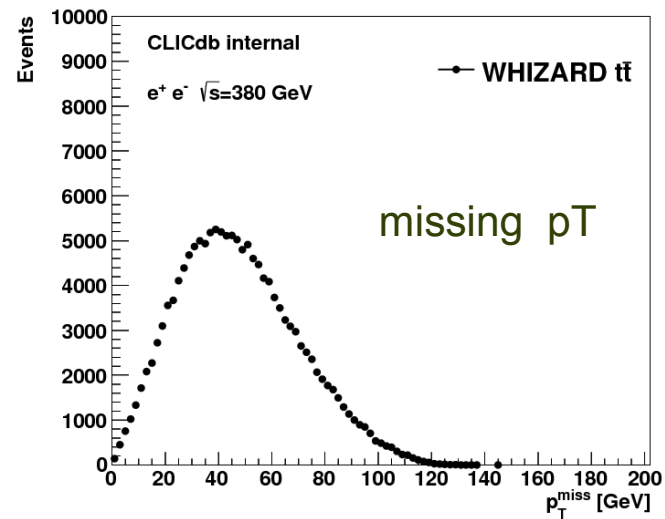
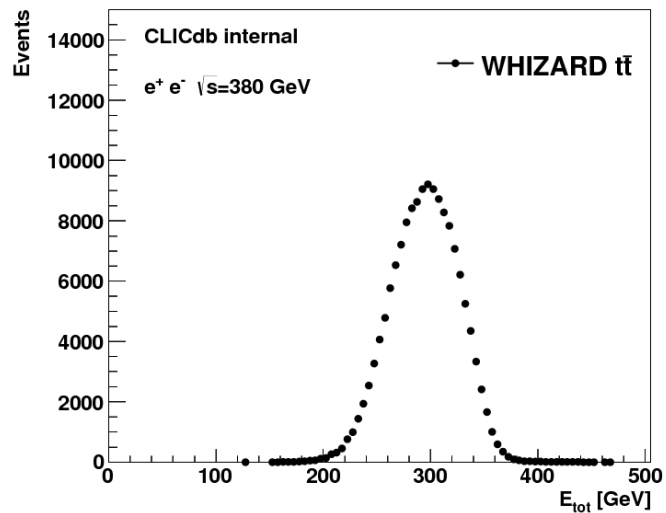
The current analysis does not use kinematic fits



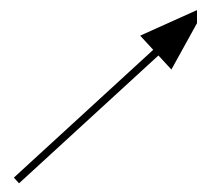
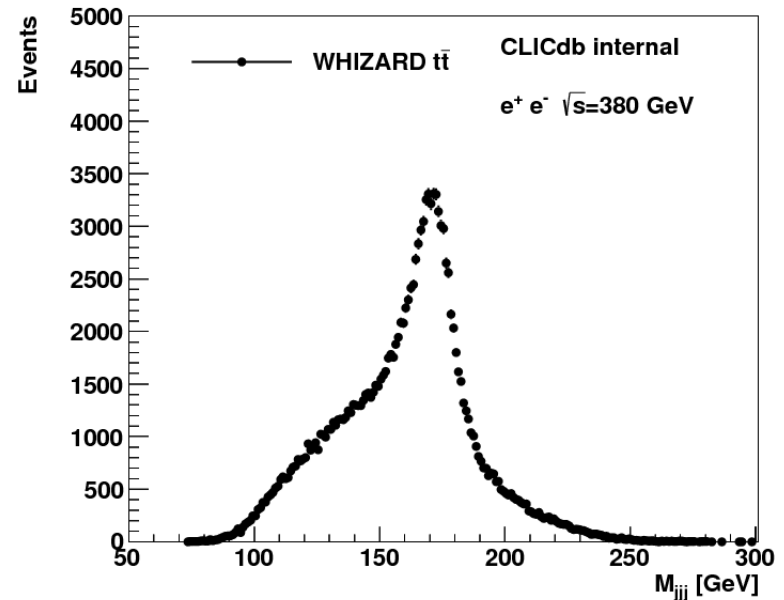
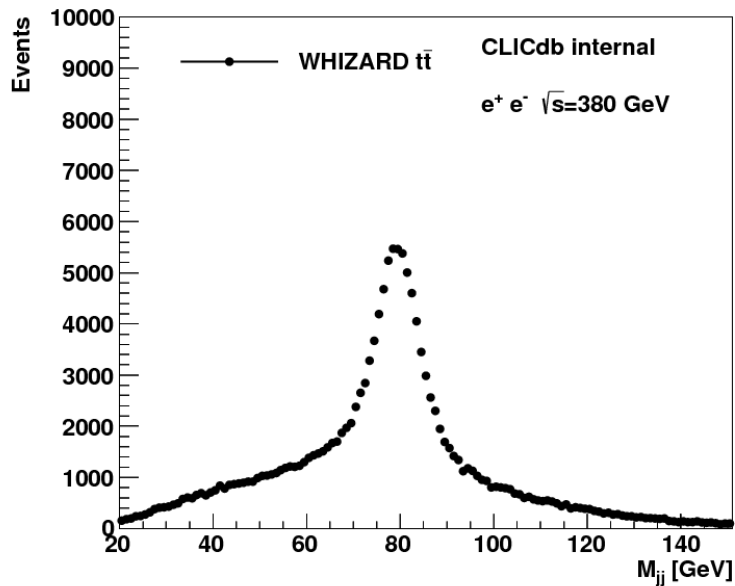
Few publications for 500 GeV:

- S.Chekanov, V.Morgunov, Phys.Rev.D67:074011 (2003)
 - TESLA& BRAHMS
 - Durham jets
 - Neural Net to reject background for hadronic top decays
- K.Seidel, F.Simon, M.Tesar, S.Poss Eur. Phys. J. C73 (2013) 2530
 - ILD (CLIC) detector
 - Used kt jets with $R=1.3$ + kinematic fits

Kinematic distributions

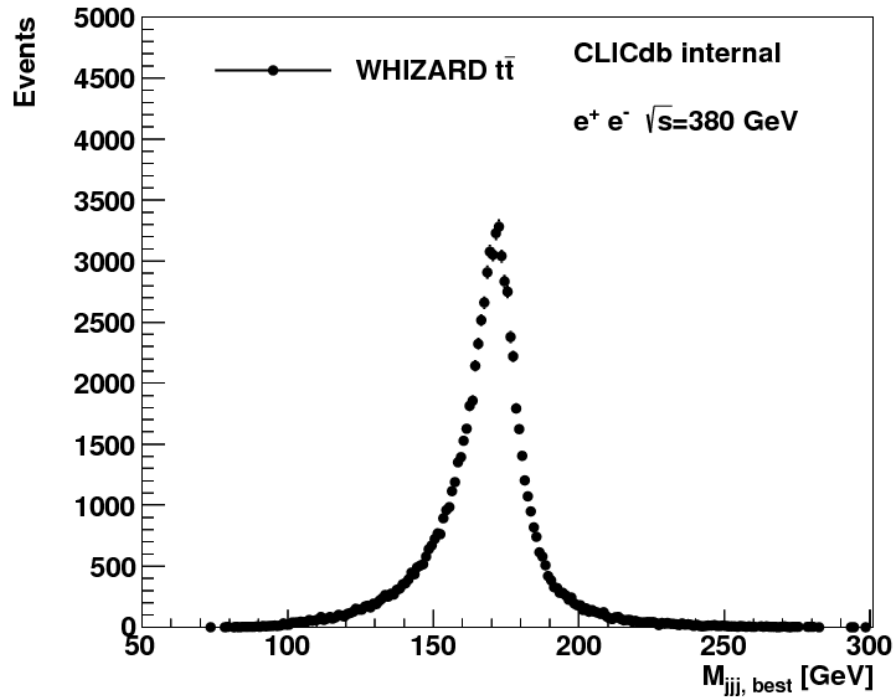


Invariant masses: M_{jj} , M_{jjj}



3-jet invariant mass (using 4-jet, where one b-jet is miss-assigned)
Can be used for mass measurements, but not for efficiency calculations

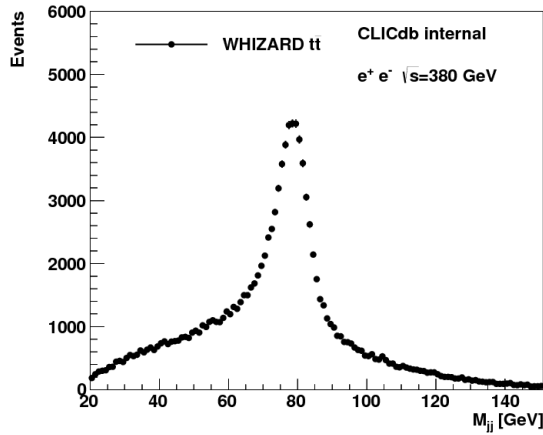
M_{jjj} closest to M(top)



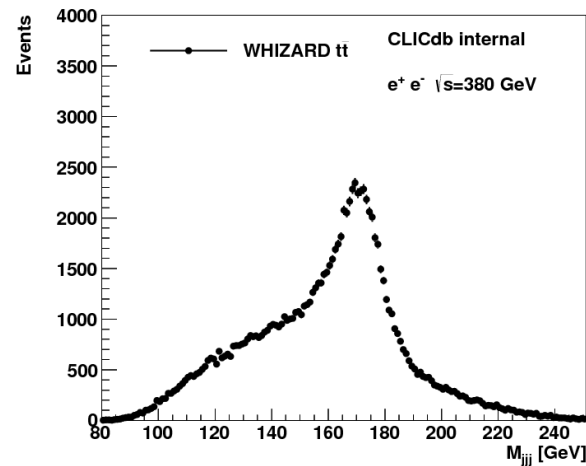
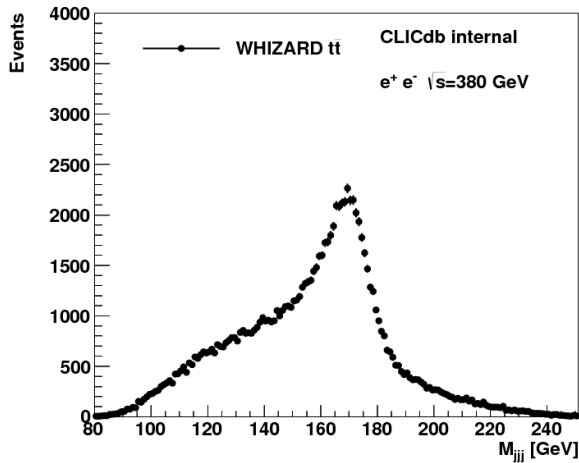
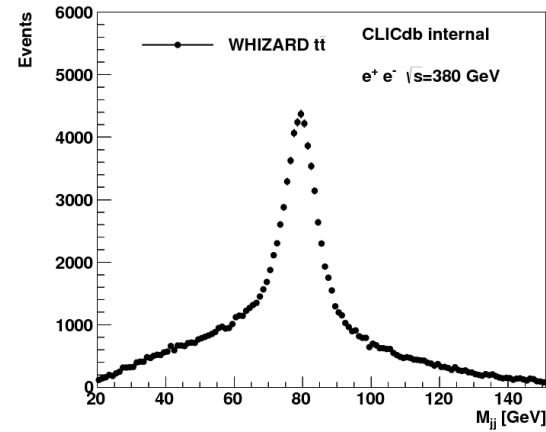
- Best (cheated) M_{jjj} combination closest to the nominal top mass
- Not good for top mass measurements, but good enough to extract top reconstruction efficiency

Invariant masses: R=1 vs R=1.3 jets

R=1.0



R=1.3

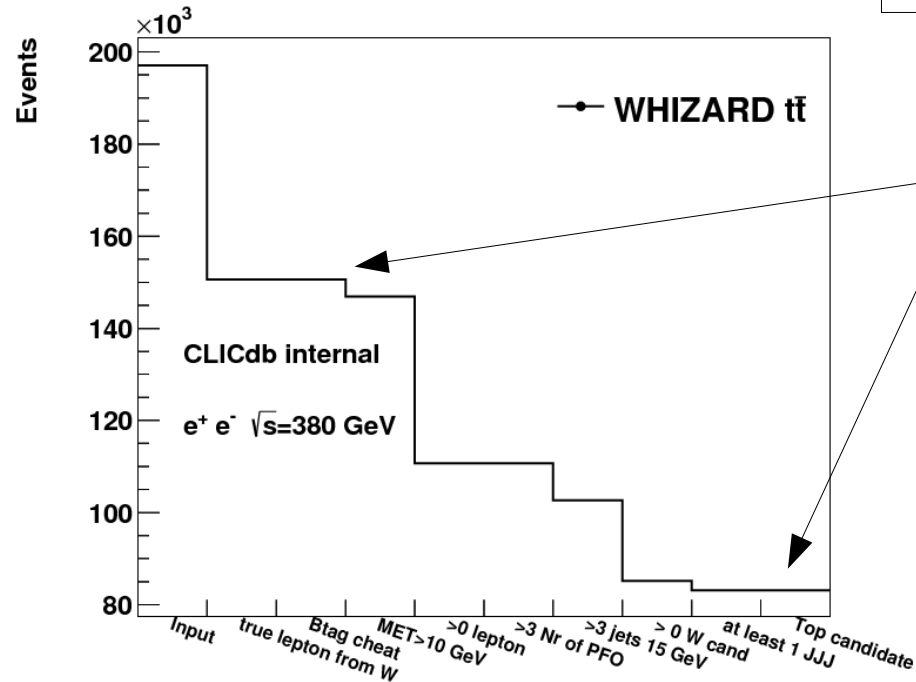


Do not observe large changes due to the jet R size

Cutflow for semileptonic top reconstruction

Analysis cutflow

efficiency = Nr of reconstructed tops / generated



150k truth events with 1 lepton from W
100k truth events (tau excluded)
83k reconstructed top quarks

Top reconstruction efficiency ~83%

Reminder:
b-tagging efficiency ~100% is assumed

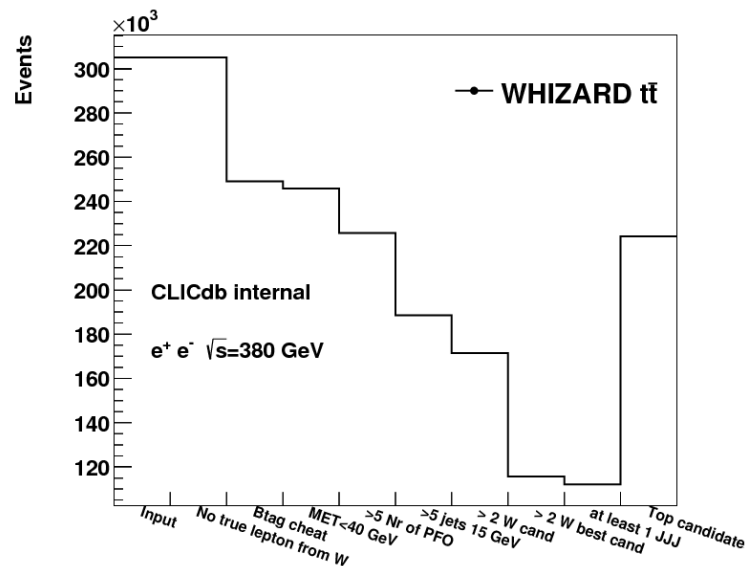
Top reconstruction in fully hadronic decays

- Use **LooseSelectedPandoraPFANewPFOs**
- No leptons with $p_T(\text{lepton}) > 20$ GeV
- missing $p_T < 40$ GeV
- Six kT jets with $R=1.0$ in exclusive mode:
 - FastJet 3.0
 - all PFO (charged+neutral)
- Jet $p_T > 10$ GeV and $|y| < 2.1$
- Use b-tagging cheating: Identify b-jets using a cone algorithm with $dR=0.3$, matching b-quark with kT jet
 - updated soon with realistic algorithm
- Identify 2 light-flavor jets for M_{jj}
- Constrain $|M_{jj} - M(W)| < 20$ GeV
- Calculate 3-jet mass

Input: 12 samples with different quark flavors created by Philipp):

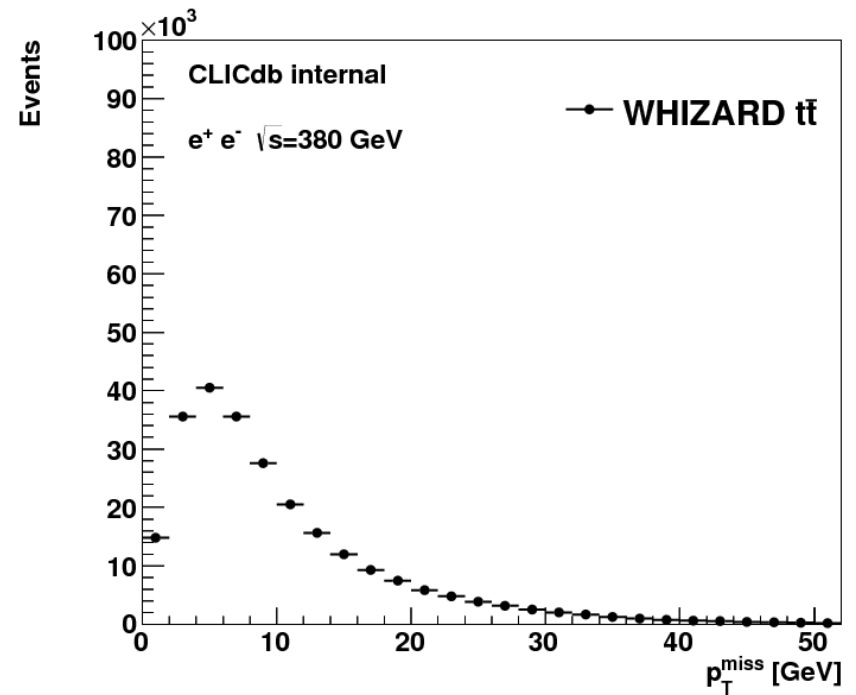
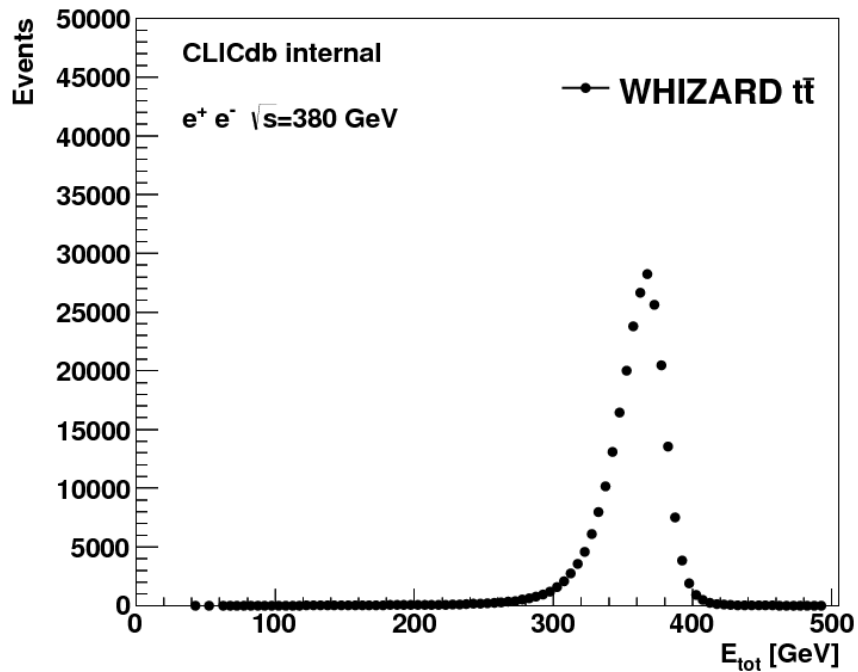
<https://twiki.cern.ch/twiki/bin/view/CLIC/MonteCarloSamplesForTopPhysics>

Analysis cutflow

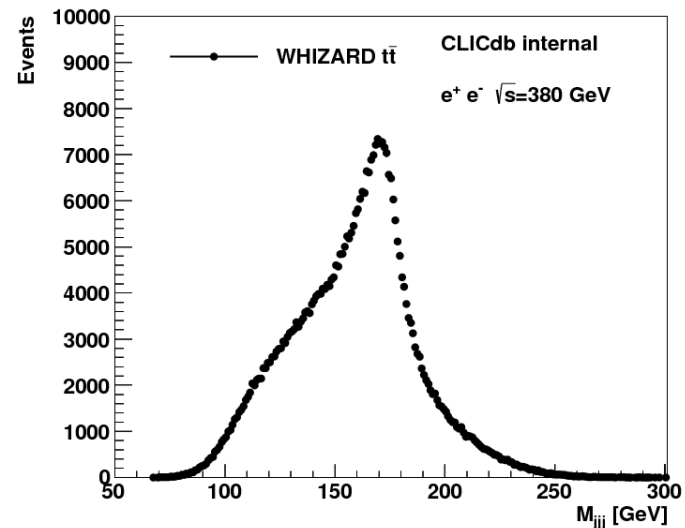
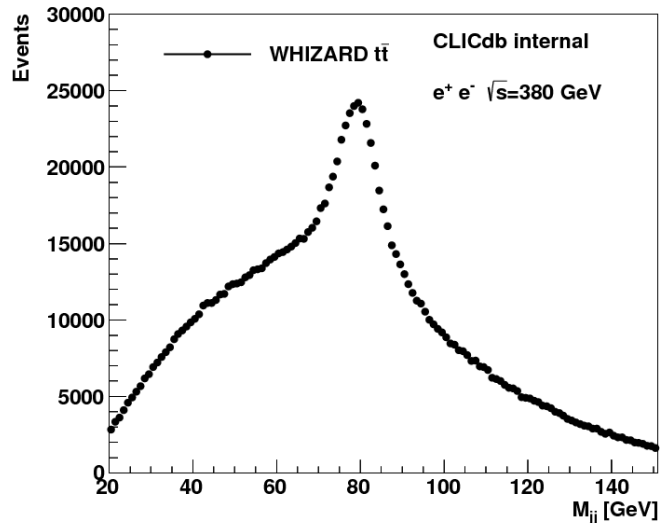


250k events without leptons from W
after cheated b-quark from top
220k top candidates
~60% top reconstruction efficiency

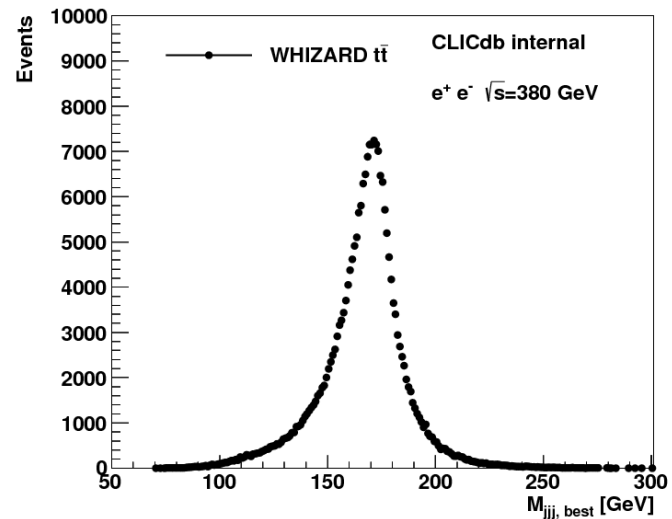
Kinematic distributions



Top reconstruction in fully hadronic decays



2 jet combinations with masses closest to the top mass
(only for efficiency studies)



Validation of $t\bar{t}$ reconstruction with CLIC o3_v13

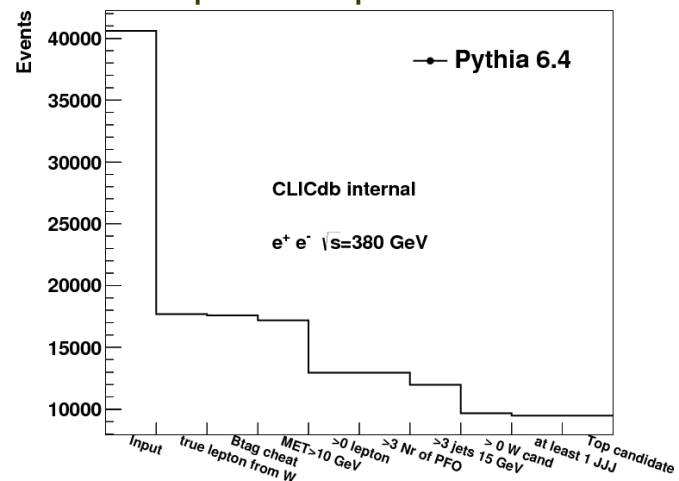
Software:

- CLIC_o3_v13 (test version under validation)
- iLCSoft. builds/2017-08-23

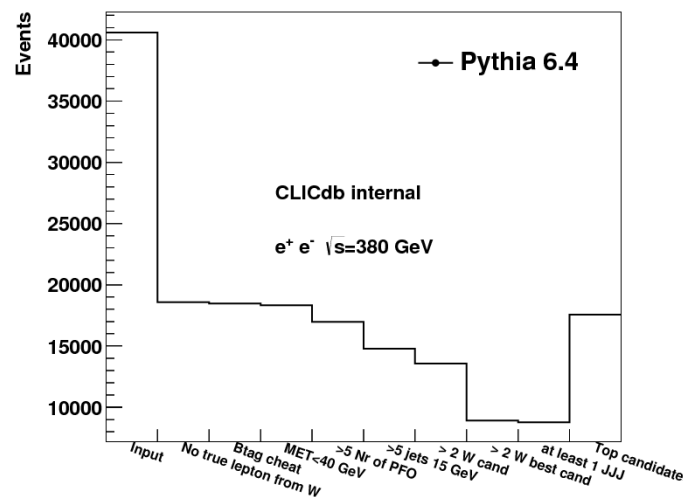
Input:

- 380 GeV CM energy
- Pythia 6.428
- [gev380ee_pythia6_ttbar](#) (from HepSim)
- All $t\bar{t}$ decays (+ all processes)
- About 40,500 input events
- No beam background included

semileptonic top reconstruction



hadronic top reconstruction



Validation of $t\bar{t}$ reconstruction with CLIC o3_v13

(DD4HEP based simulation)

Compare M_{jjj} for:

- Whizard+CLIC ILD
- Pythia6 (all decay) with CLIC o3 v13 (DD4HEP+Marlin)

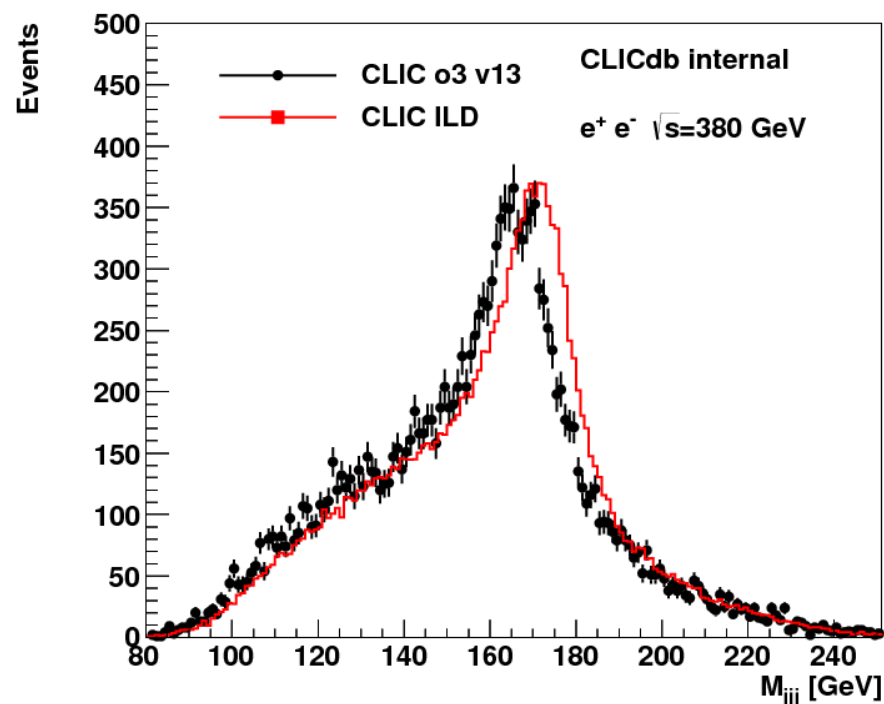
New development in Pythia8

- several e^+e^- tunes
- new particle composition
- updated hadronisation parameters
- etc.

Current problem:

DD4HEP & Pythia8 MCParticle do not talk to each other (work with A.Sailer)

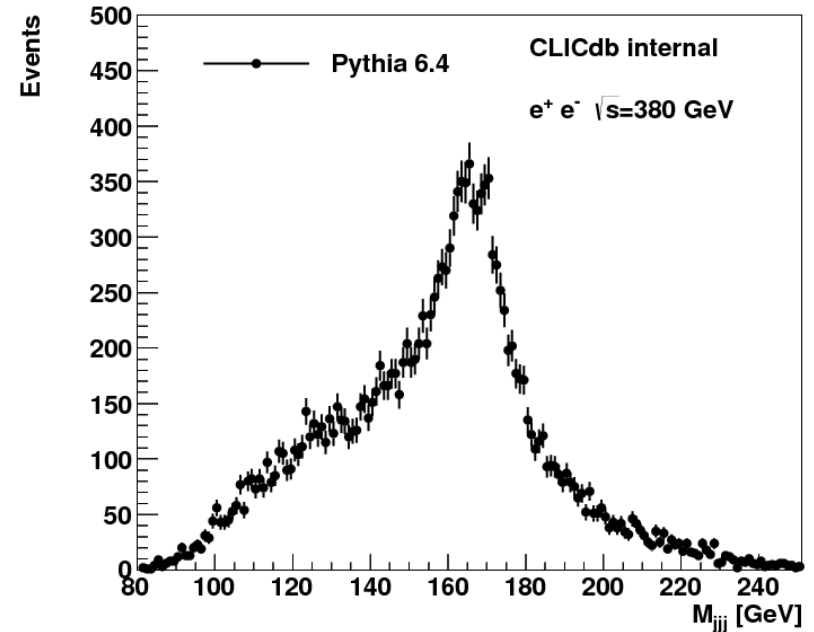
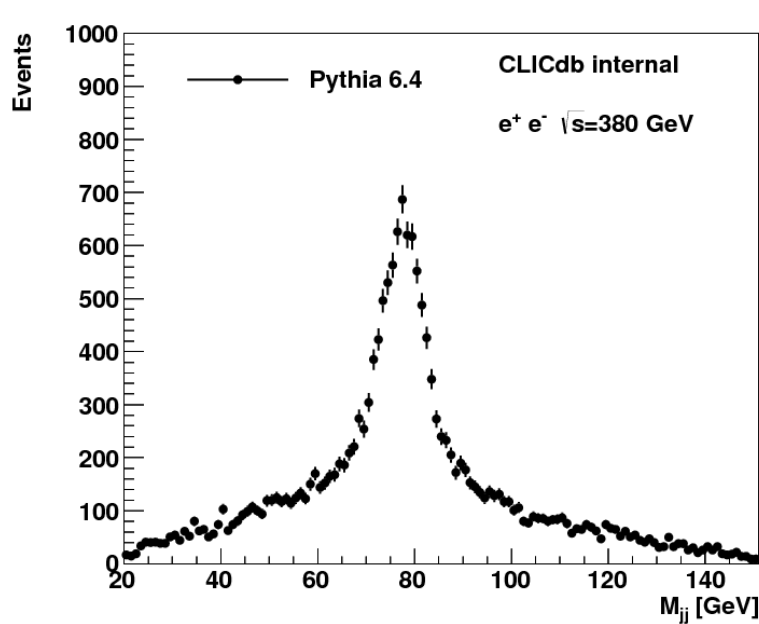
semi-leptonic top production



A shift with the CLIC ILD simulation was observed. Need a closer look

Semileptonic production

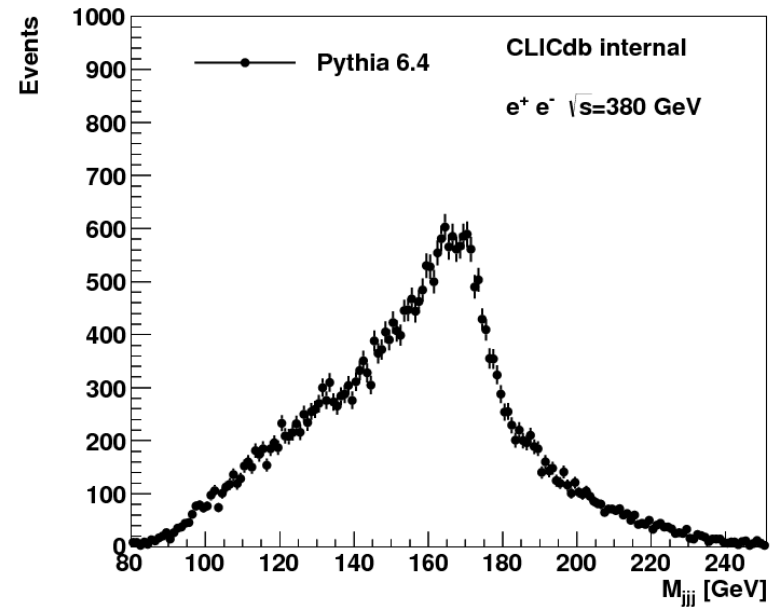
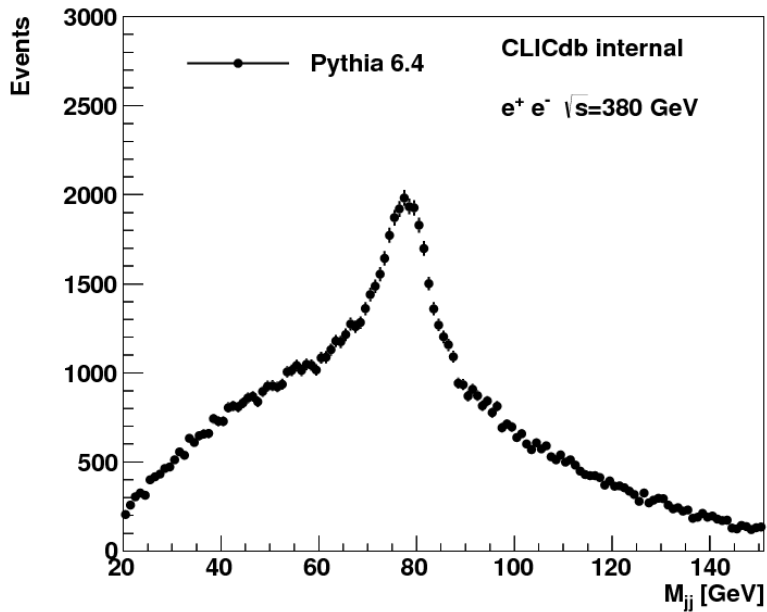
CLIC_o3_v13



distributions look similar to the ILD simulations

Hadronic $t\bar{t}$ production

CLIC_o3_v13



distributions look similar to the ILD simulations

Summary: Work in progress

- **First look at the $t\bar{t}$ samples using 380 GeV CM energy**
- **Need to include realistic b-tagging from Nacho G. Garcia**