Top Analysis in the HEC group at MPI

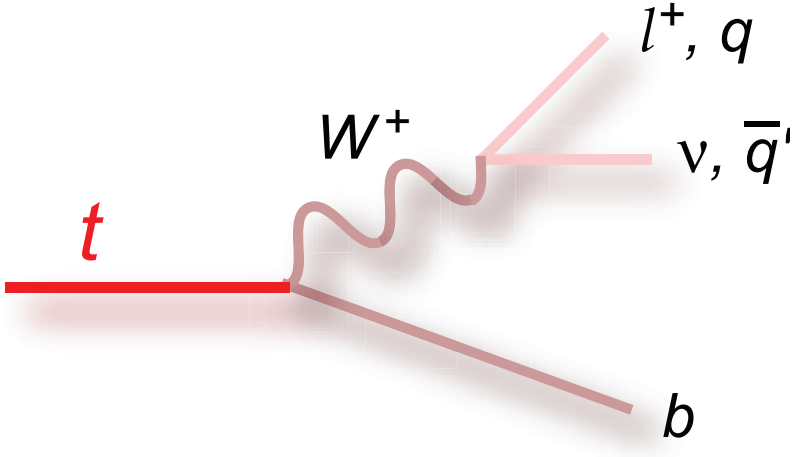
Teresa Barillari Isabelle and Luis visit MPI Munich, 26 February 2009

- Introduction
- $t\bar{t}$ pair production
- lepton+jets and all-jets events
- Event selection
- "P_T balance method" and "Max P_T method"
- Results
- Outlook and conclusions

Introduction

- The top quark differ from the other quarks, it is much heavier

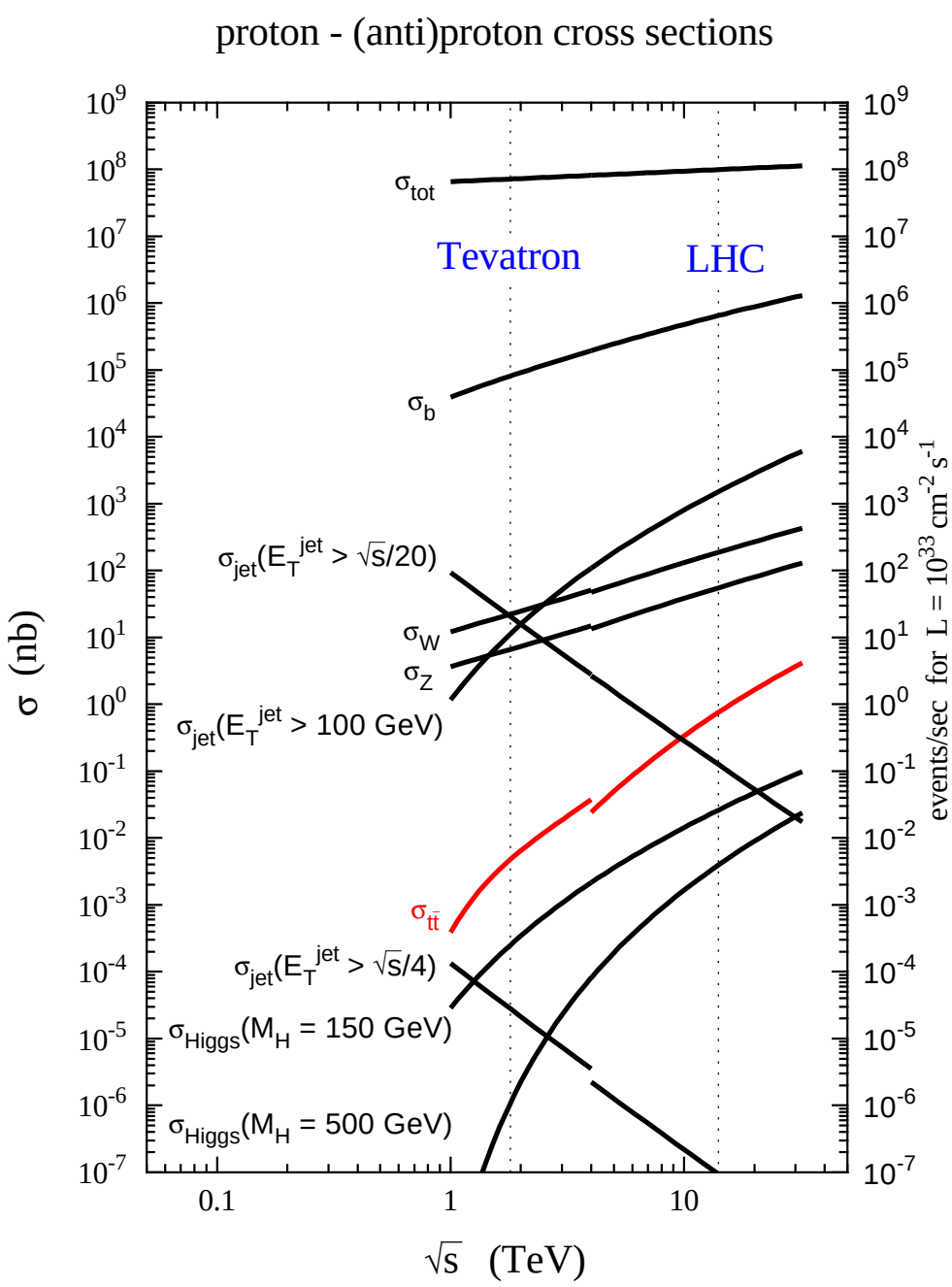
- It can decay in $t \to Wq$ ($q = d, s, b$),
- The Ws and Wd final states expected to be suppressed relative to the Wb by the square of the CKM matrix elements V_{ts} and V_{td}
- Main top decay: $t \to Wb$



- With a $m_t = 180\,\text{GeV}$ the predicted decay width is $\Gamma \approx 1.56\,\text{GeV}$, and its lifetime $\tau = \Gamma^{-1} \approx 5\text{x}10^{-25}\,\text{s}$
- The final states for the leading $t\bar{t}$-production process can be divided in three main classes:
  - All-jets: $t\bar{t} \to W^+bW^-\bar{b} \to q\bar{q}'bq''\bar{q}'''\bar{b}$ (46.2%),
  - Lepton+jets: $t\bar{t} \to W^+bW^-\bar{b} \to q\bar{q}'bl\overline{\nu_l}\bar{b} + \bar{l}\nu_l bq\bar{q}'\bar{b}$ (43.5%),
  - Dilepton: $t\bar{t} \to W^+bW^-\bar{b} \to \bar{l}\nu_l bl'\overline{\nu_{l'}}\bar{b}$ (10.3%)

$t\bar{t}$-production: total cross section

- LHC will be a top factory
- Total cross section for $t\bar{t}$-production is about a factor of 100 larger at LHC than at Tevatron
- $\sigma_{t\bar{t}}(14.0\,\mathrm{TeV}) = 800\,\mathrm{pb}$

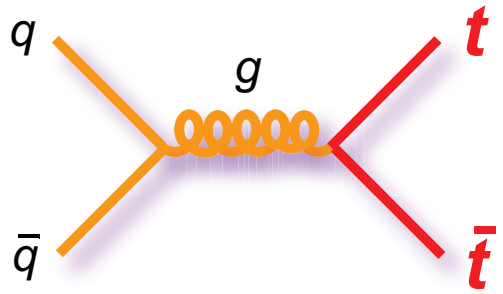


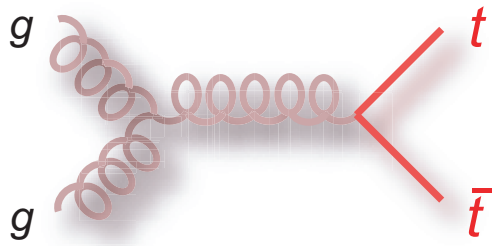
W.J. Stirling, 1998

$t\bar{t}$-*production*

- $q\bar{q}$ annihilation

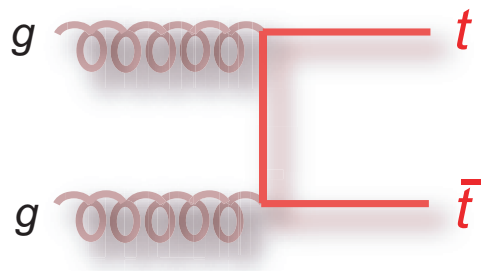
$\sqrt{s}$	$\sigma_{q\bar{q}\to t\bar{t}}/\sigma_{t\bar{t}}$
1.8TeV	90%
14TeV	5%

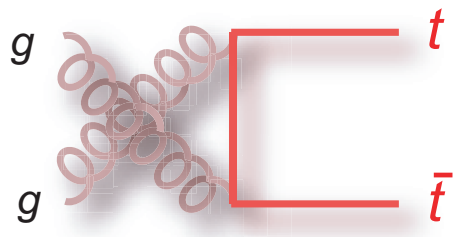




- Gluon fusion

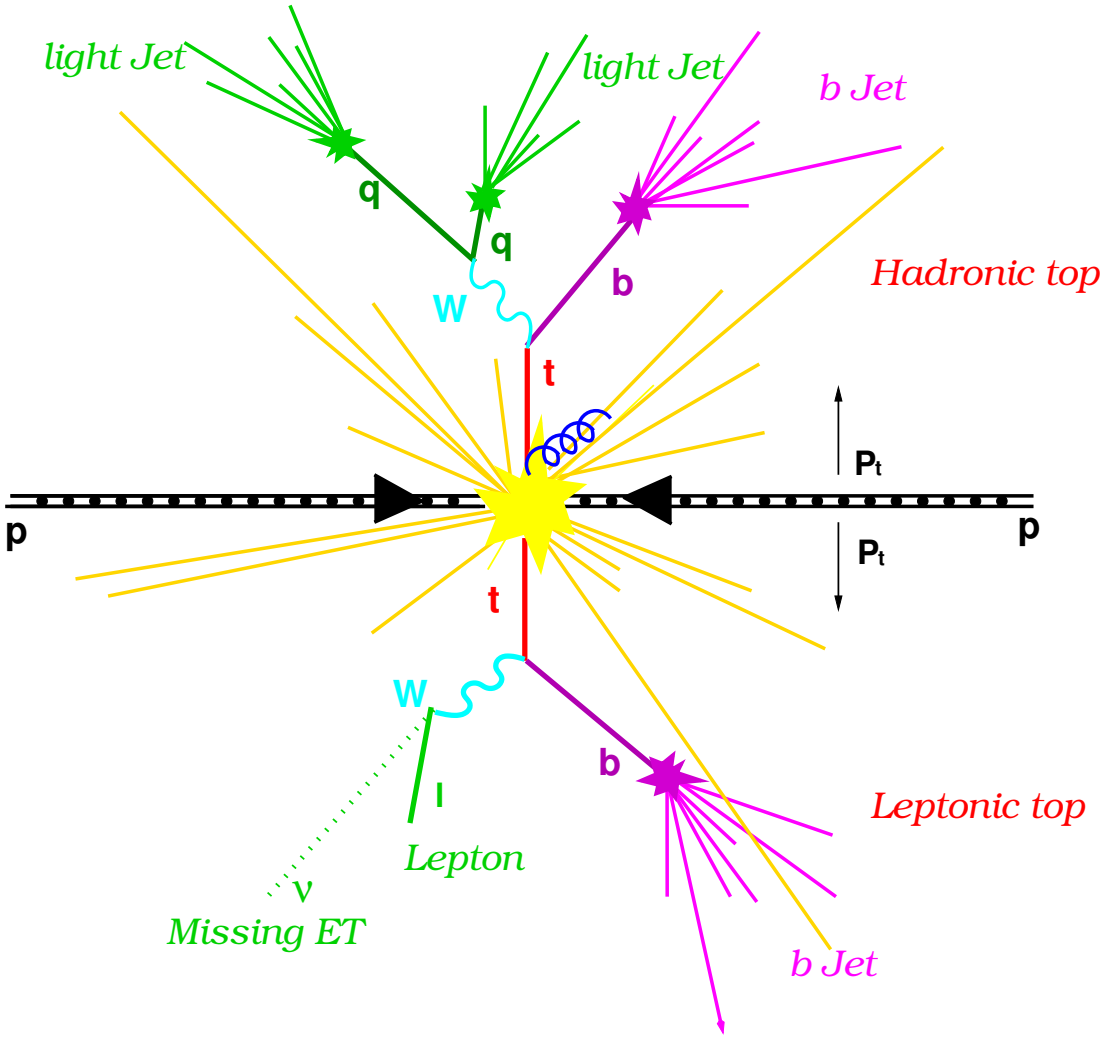
$\sqrt{s}$	$\sigma_{gg\to t\bar{t}}/\sigma_{t\bar{t}}$
1.8TeV	10%
14TeV	95%





- At LHC the $gg \to t\bar{t}$ dominates over the $q\bar{q} \to t\bar{t}$

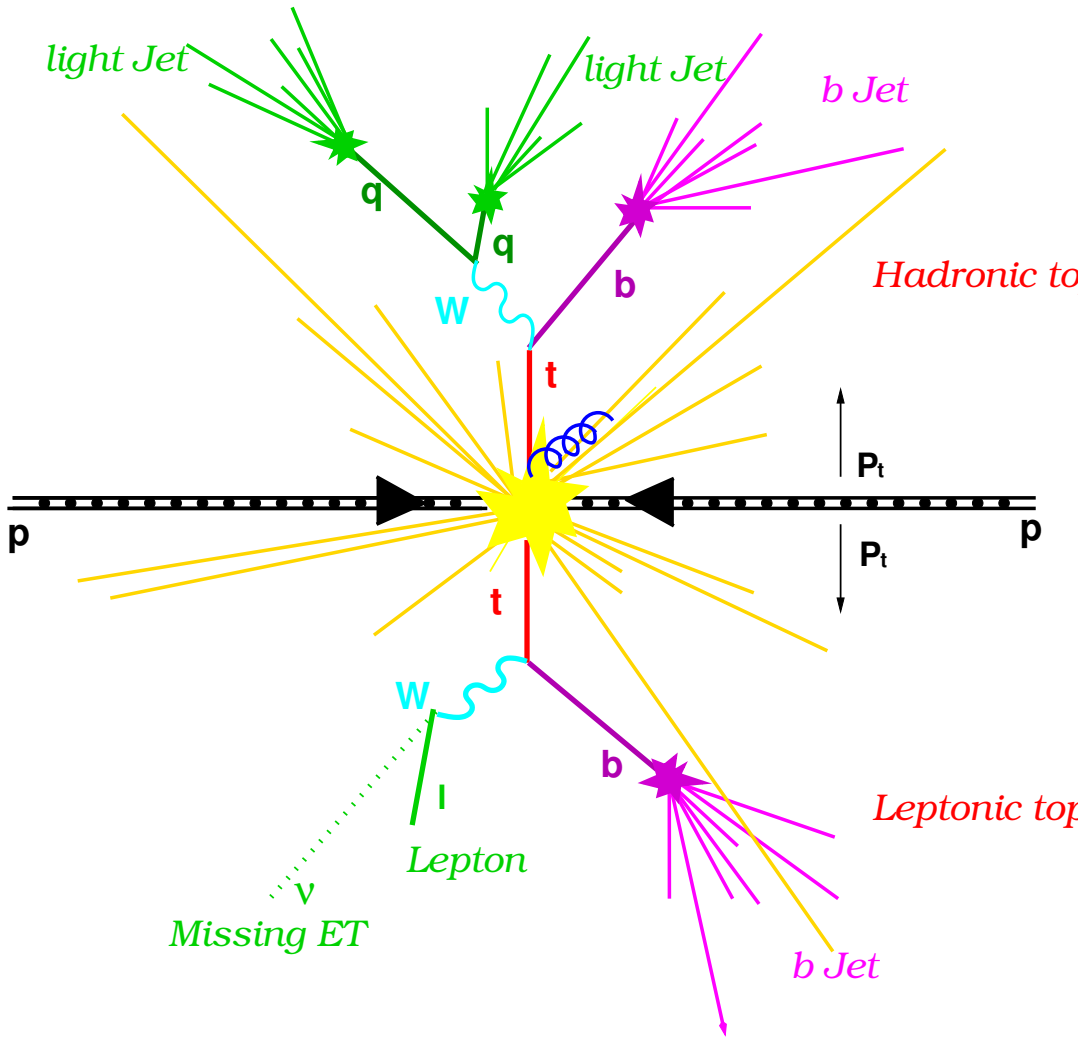
Experimental challenges



- $t\bar{t}$ events provide:
  - Jets with a wide spectrum of $p_\perp$
  - b-jets
  - Lepton(s)
  - Missing ET
  - ... etc., etc.
- The whole detector capability needed
- $t\bar{t}$ are, for us at MPI, a good sample of events for calorimeter calibration studies

Golden plated event $t\bar{t} \rightarrow WWb\bar{b} \rightarrow (l\nu)(jj)b\bar{b}$

- We are involved in the top mass measurement in "lepton + jets" (Emanuel, Andreas, Sven and myself) and "all-jets" (Paola) $t\bar{t}$ events
- The "lepton+jets" is the golden channel: one W decays leptonically (e, μ) and the other W decays hadronically
  - Clean trigger from the isolated lepton
- The reconstruction starts with the W mass:
  - JES using the W
- Important to tag the b-jets:
  - Reduces the background
  - Clean top quark samples
- Main background comes from W + Jets events
- S/B $\approx$ 10



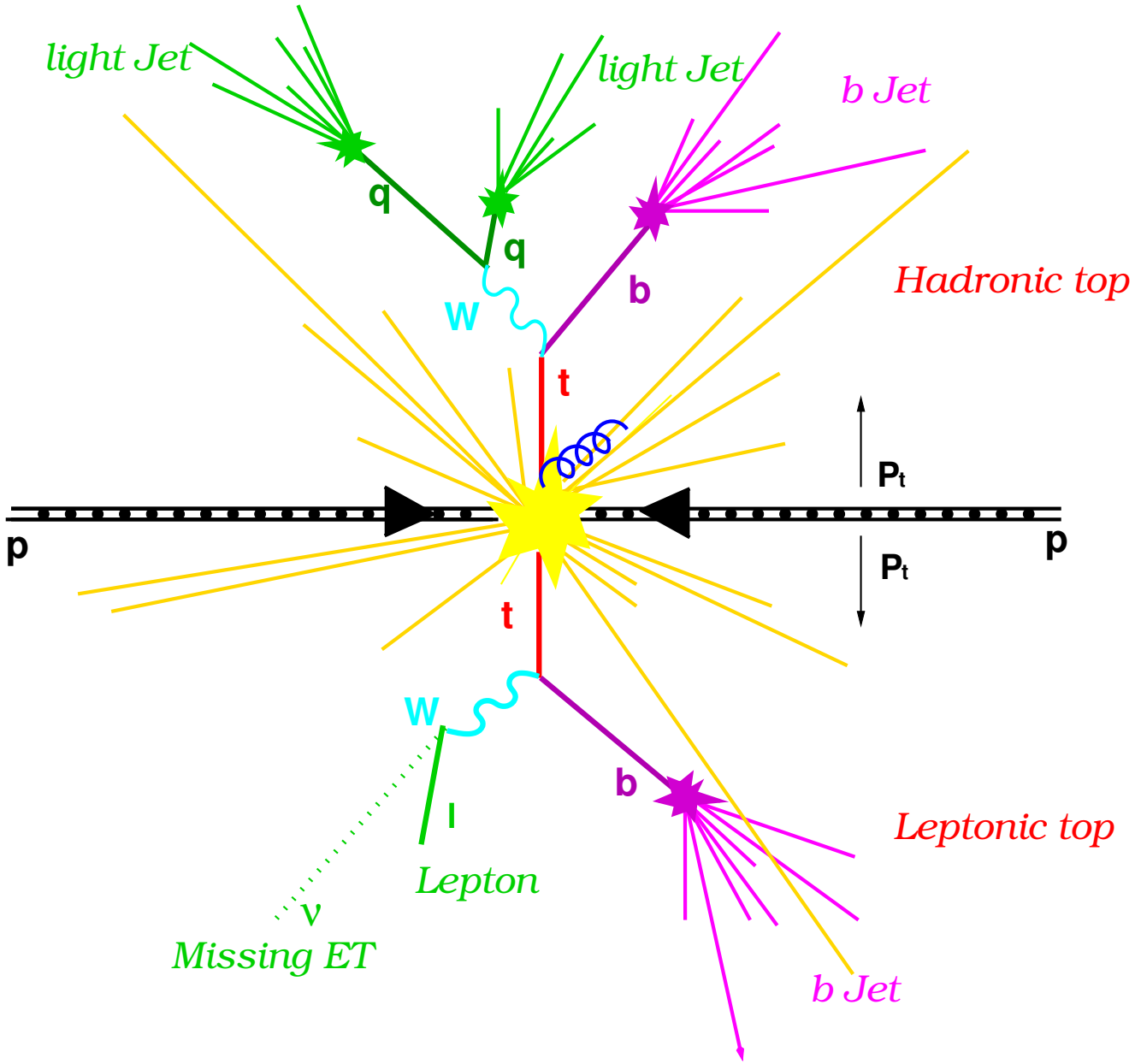
All-jets events: $t\bar{t} \rightarrow WWb\bar{b} \rightarrow (jj)(jj)b\bar{b}$

- The all-jets channel is the most copious $t\bar{t}$ final state. Here both W's decay hadronically
- The signal is overwhelmed by the background coming from QCD multijets production
- Use trigger to reduce background
  - The ATLAS multijet-trigger
- The reconstruction starts with the W mass:
  - JES using the W
- Important to tag the b-jets:
  - Reduces the background
  - Clean top quark samples
- S/B $\approx 10^{-4}$ without btagging
- The performance of jets with local hadron calibration is studied in both "lepton + jets" and "all-jets" channels, using different jet algorothms

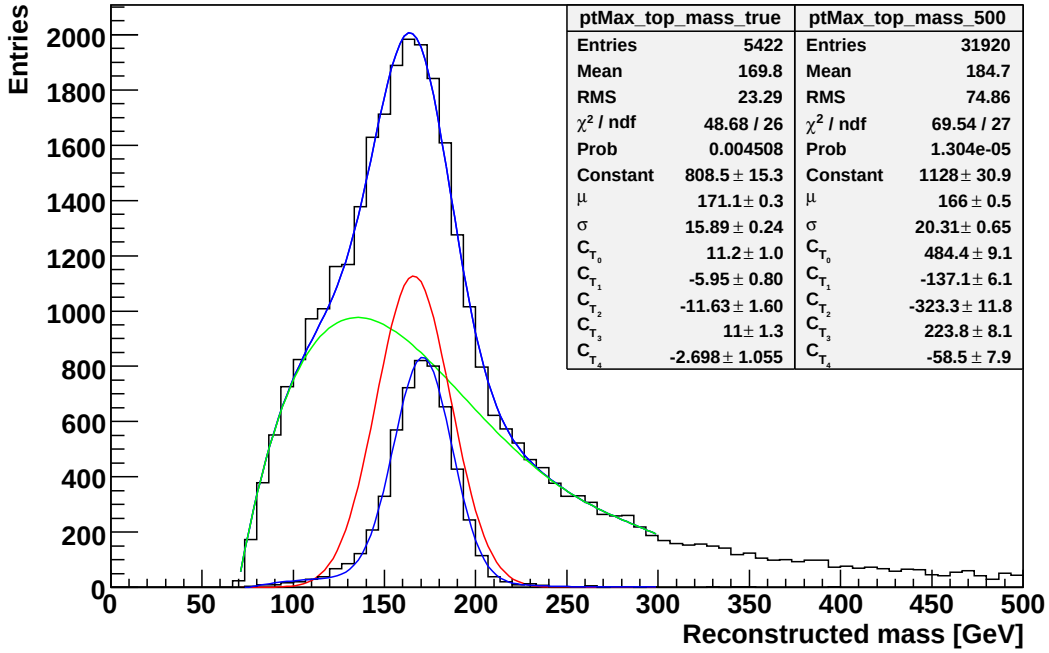
Event Selection

- Jets selection:
  - 3 jets with $p_\perp > 40$ GeV
  - 1 jet with $p_\perp > 20$ GeV
  - $|\eta| < 2.5$
- Exactly one isolated electron or muon with:
  - $p_\perp > 20$ GeV, $|\eta| < 2.5$
  - Muons reconstructed with STACO; electrons with eGamma and isEM $= 0$
- MET > 20 GeV
- Use the P_T balance method (Teresa and Paola) to combine the good selected jets into hadronic top and and study the W
  - B-tag used on two jets to decrease the combinatorial background
  - Exclude events with the HEC C Quadrant 8 missing
- Use the "Maximum P_T method" (Emanuel, Andreas) to combine the triplet of jets with max P_T to obtain the top mass
  - This method can be used with early data, it doesn't use btagging

Lepton + jets event



Top mass with the Maximum Pt method



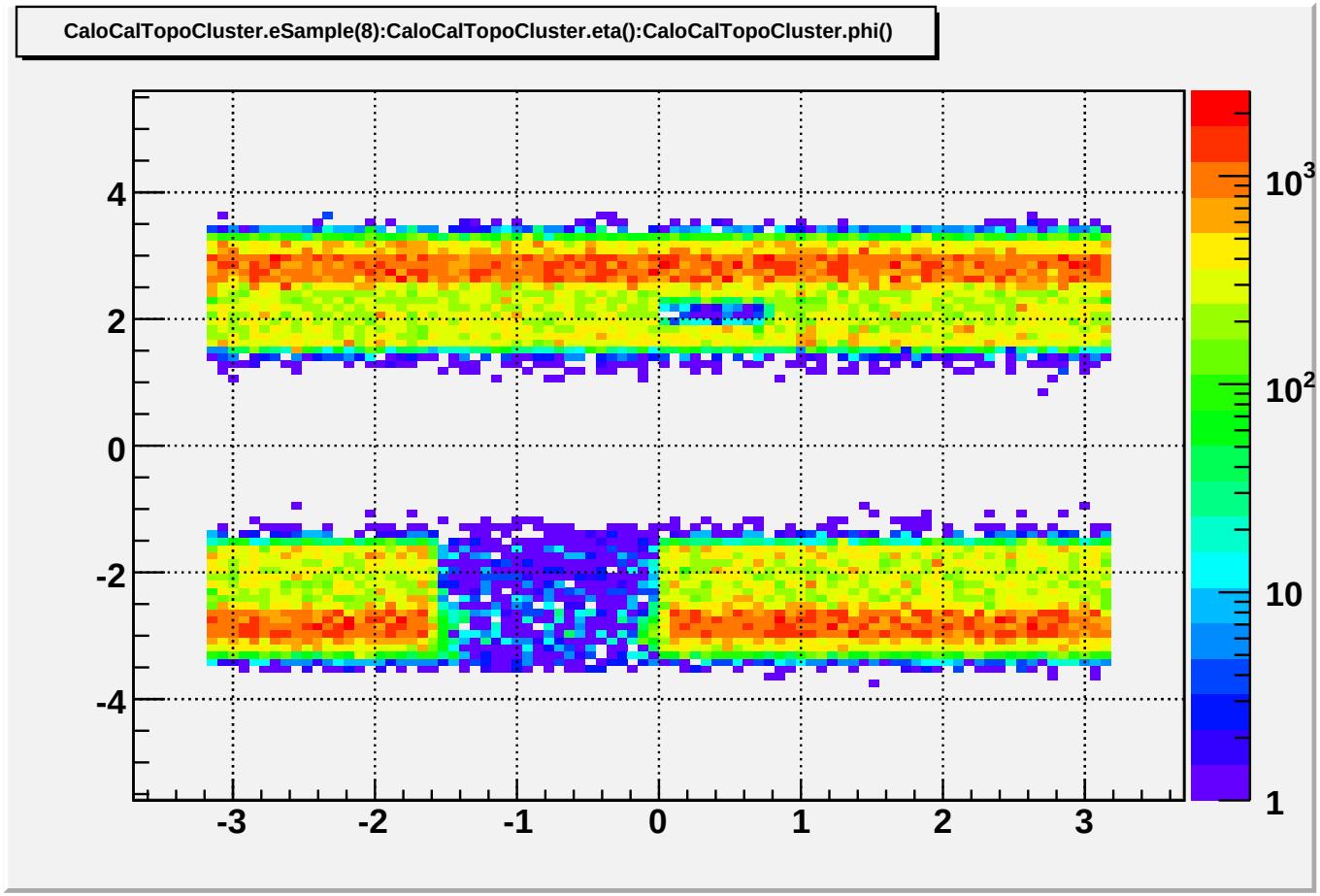
- Top mass obtained (Emanuel) with Kt4 jets with local hadron calibration using 105200 MC data

DPDs with $t\bar{t} \rightarrow WWb\bar{b} \rightarrow (l\nu)(jj)b\bar{b}$ *events*

- The data analyzed here are $t\bar{t} \rightarrow WWb\bar{b} \rightarrow (l\nu)(jj)b\bar{b}$
- DPDs, have been produced with release 14.2.21,
- Data sample used: 105200 Task ID=26357 with the HEC C Quadrant 8 missing
- These DPDs contain the following extra jet containers "with B-tag information":
  - k_T 4LCTopoJets: k_T 4 topo-jets with LC
  - k_T 6LCTopoJets: k_T 6 topo-jets with LC
  - Cone4LCTopoJets: Cone4 topo-jets with LC
- Results with the default Cone4 jets are also presented:
  - Cone4H1TowerJets: tower-jets with H1
- The default jets Cone4H1TopoJets could not be used in the analysis because they don't have B-tag information. I could not rebuild the H1 jets from the AODs

Dataset 105200 *with HEC C Quad.* 8 *missing*

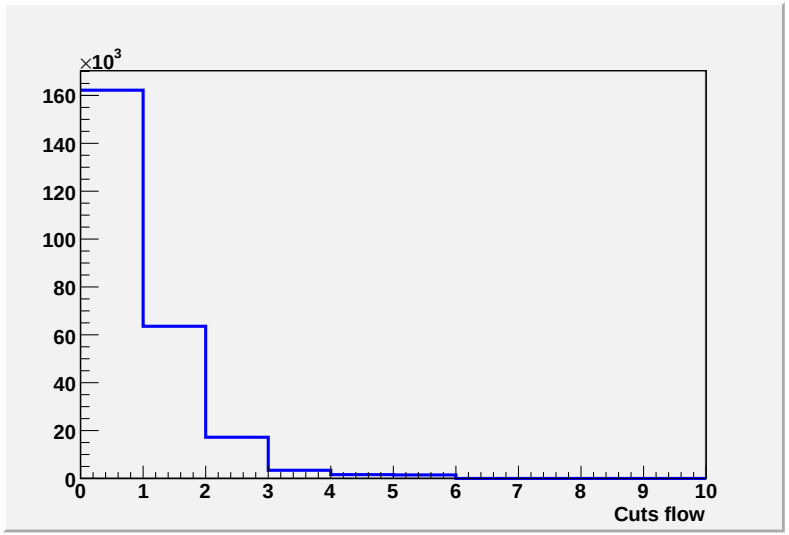
- Plot shows the cluster energy reconstructed in the front part of HEC1 wheel (HEC sampling 1) for HEC A and HEC C



- The dark violet area within $-3.2 < \eta < -1.5$ and $\pi/2 < \phi < 0$ shows the missing quadrant on the HEC C side. The other small dark violet area is a FEB missing on HEC A

Event selection cut-flow

- Plot shows how many events are left after each main cut applied in the event selection

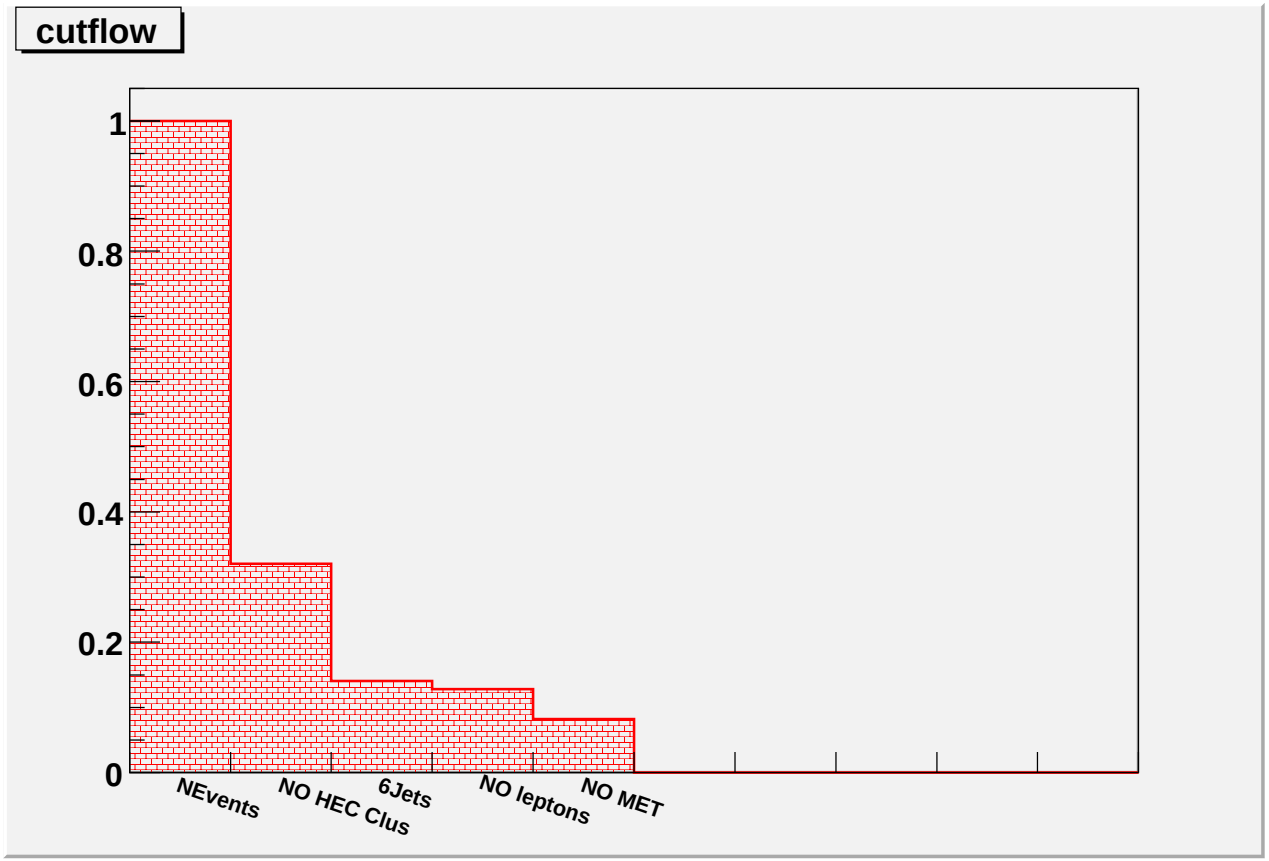


- Bin1: Total number of events
- Bin2: $\approx 40\%$ of the events remain after the missing HEC quadrant cut,
- Bin3: $\approx 27\%$ of events remain after requiring to have 3 jets with $p_\perp > 40$ GeV and 1 jet with $p_\perp > 20$ GeV
- Bin4: $\approx 20\%$ of events remain after the requirement to have a combination of 4 good jets: 2 B-jets and 2 light-jets
- Bin5: $\approx 47\%$ of the events remain by asking to have a good e or μ
- Bin6: $\approx 92\%$ of the events remanin after the MET cut

- Final selection efficiency using the P_T balance method $\approx 1\%$
- Most of the events lost in Bin2 (quadrant missing) and Bin4 (jet B-tag)

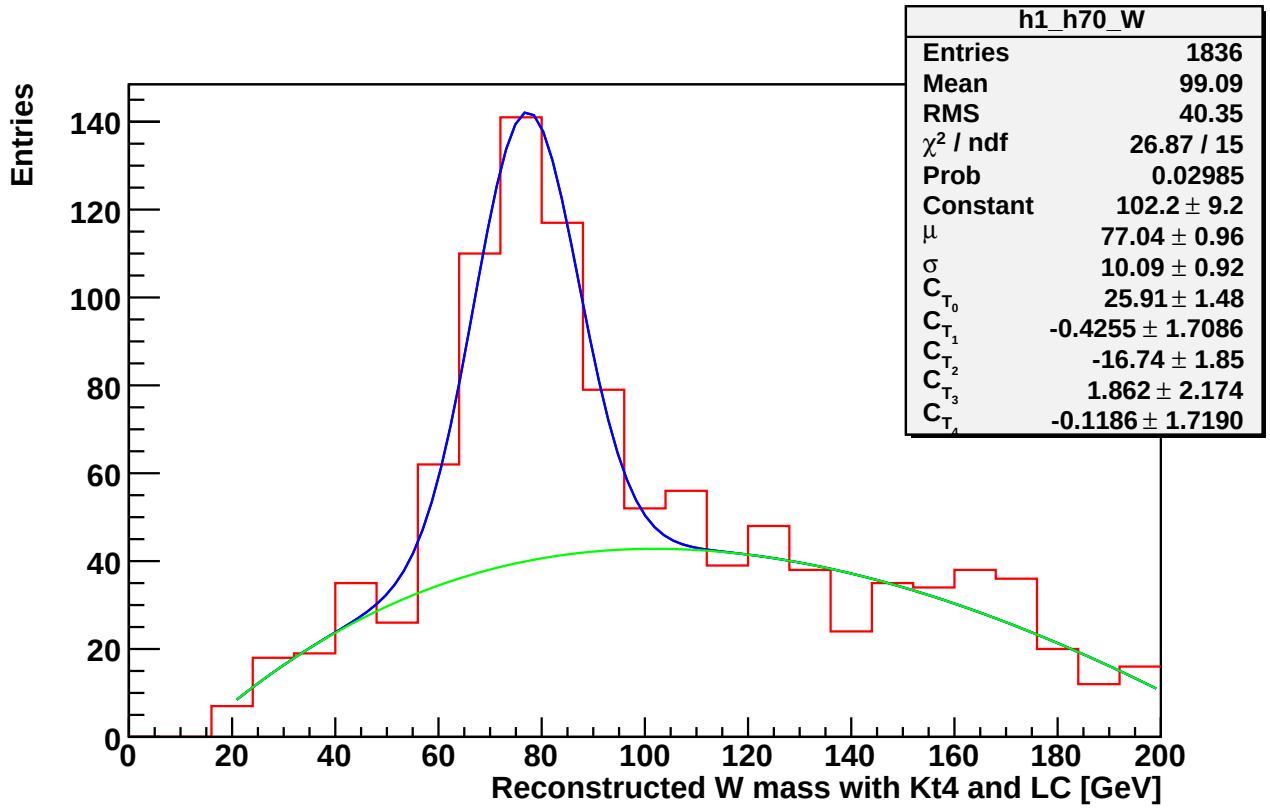
All-jets cut flow

- Plot shows how many events are left after each main cut applied in the event selection in all-jets $t\bar{t}$ events (Paola)



W mass with k_T 4 jets and LC

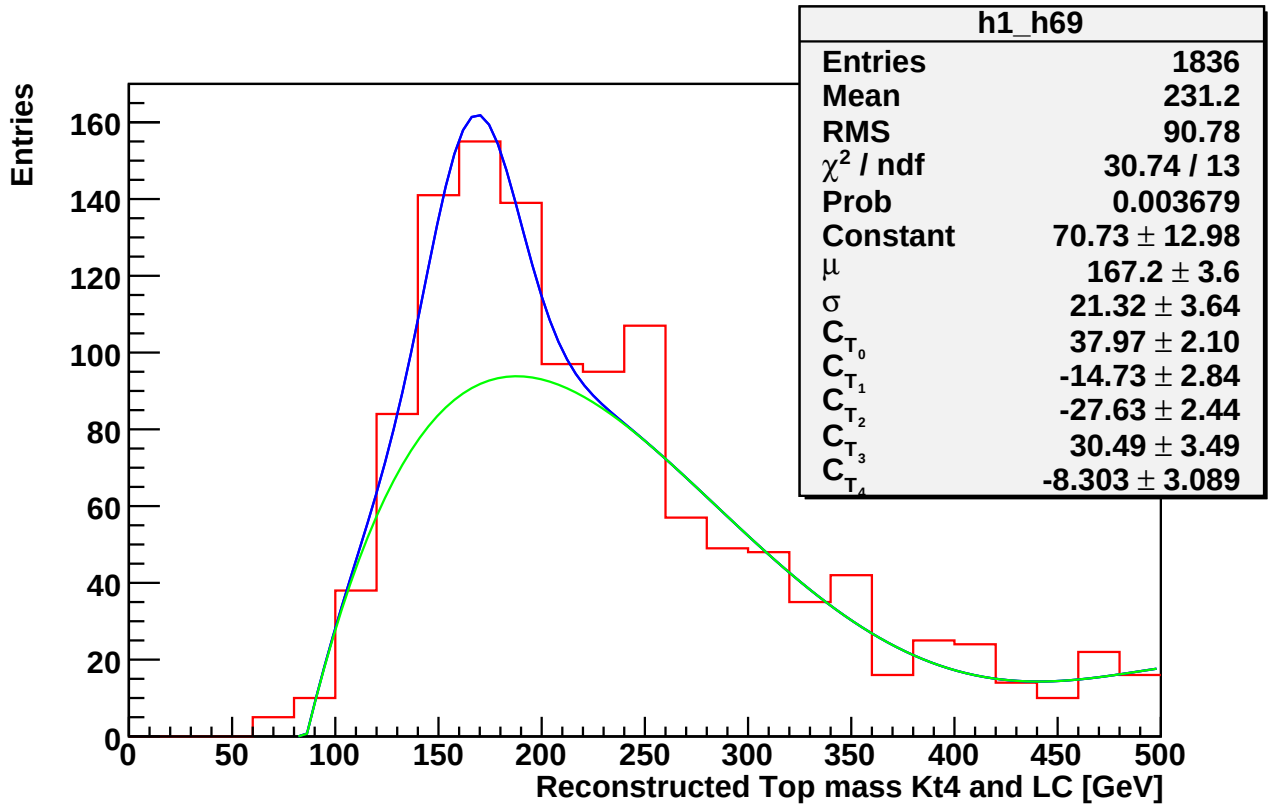
- The plot shows the reconstructed W-mass obtained using k_T with parameter $R = 0.4$ and LC



- Even though the final statistic is low a good W mass measurement can be obtain using k_T 4 jets and LC

Top mass with k_T 4 jets and LC

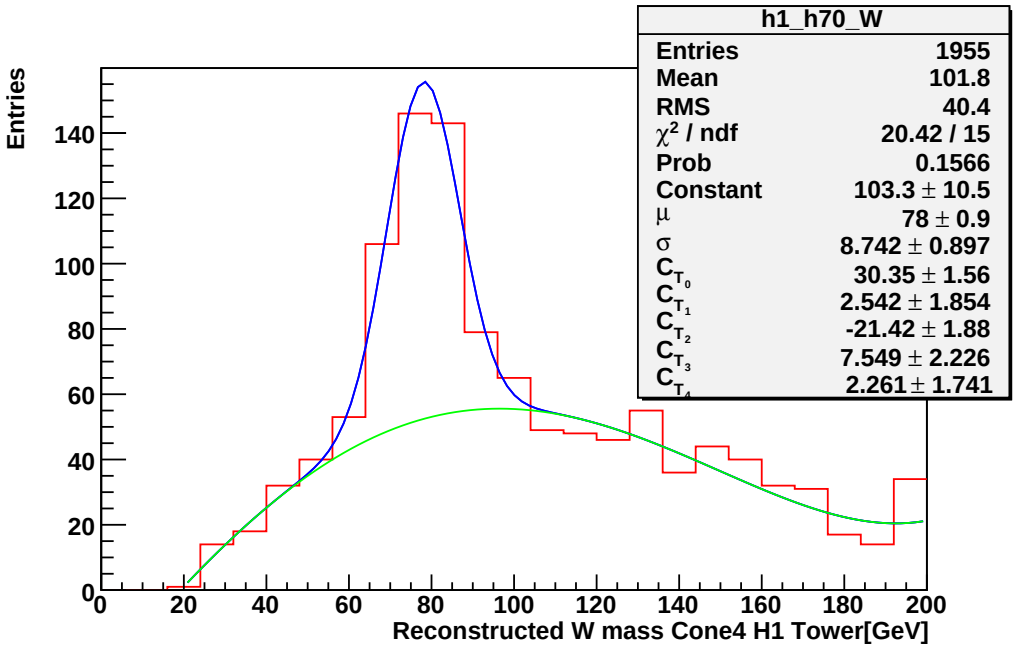
- Reconstructed Top-mass k_T 4 with LC

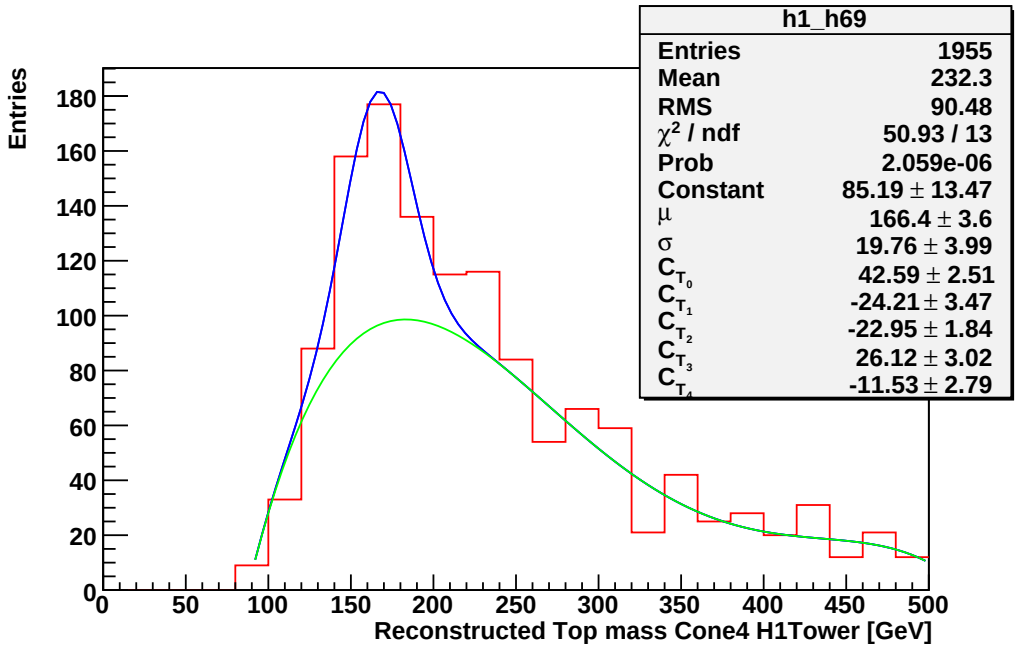


- The statistic is low, but a good Top mass measurement can be obtain using k_T 4 jets LC and the P_T balance method

W and Top mass with Cone 4 jets

- Reconstructed W mass (left plot) and Top mass (right plot) obtained using Cone 4 with H1 Tower jets

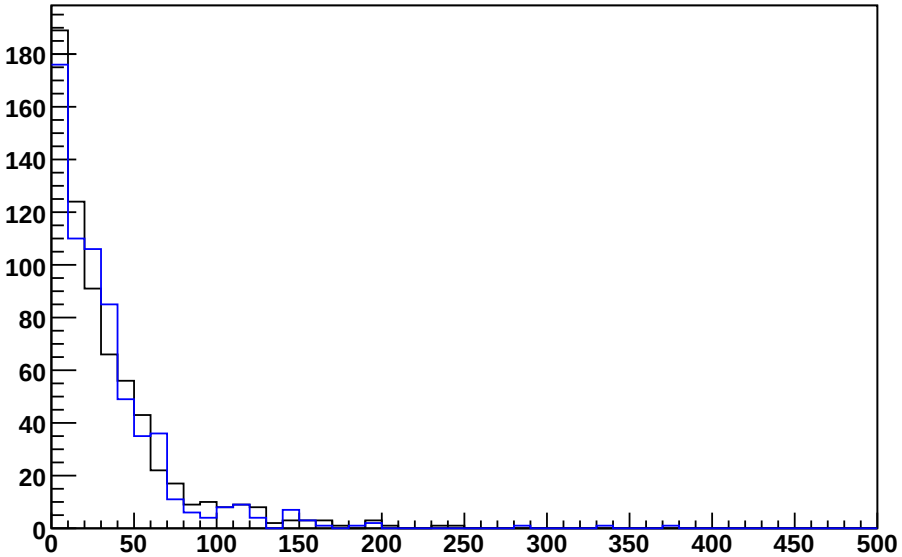


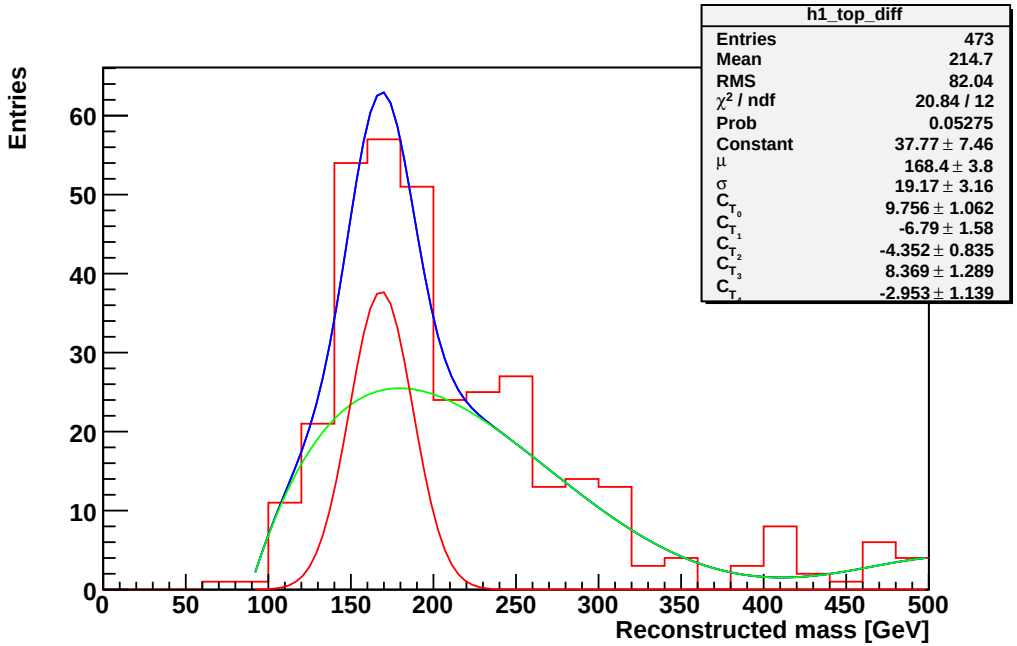


- The W and the top mass distributions obtained with the Cone 4 H1 Twoer jets are compareble with the results obtained with k_T 4 LC jets

Unbalanced Top mass

- Reconstructed Top mass (left plot) obtained using k_T 4 LC jets after requiring to have $t\bar{t}$ events P_T balanced within 10 GeV





- This cut helps cleaning the tail of the top mass distribution

Outlook and Conclusions

- A lot of work is on going in our group (Emanuel, Andreas, Paola, Sven, myself) to study the the performance of jets with LC in $t\bar{t}$ events (lepton+jets and all-jets)
- The aim of each work is also to understand the in-situ measurements of the JES with $W \longrightarrow jj$ using $t\bar{t}$ events
- Study b-jets scale ??!
- So far we have seen that comparable results can be obtained using jets with H1 calibration and jets with LC. Even though the jets with LC have a 5% offset at higher jet energy value. This is going to be fixed in the next release
- With the P_T balance method and the Max P_T method (work from Emanuel and Andres) is possible to achieve good W mass and top mass measurements
- Improve our top mass measurements methods
- Study background events
- Work is on going to study performance CALOJet DPDs and check if all kind of jets can be build from these DPDs, and also if any top analysis can be done using these DPDs ... looking forward for real data