ttH Status report

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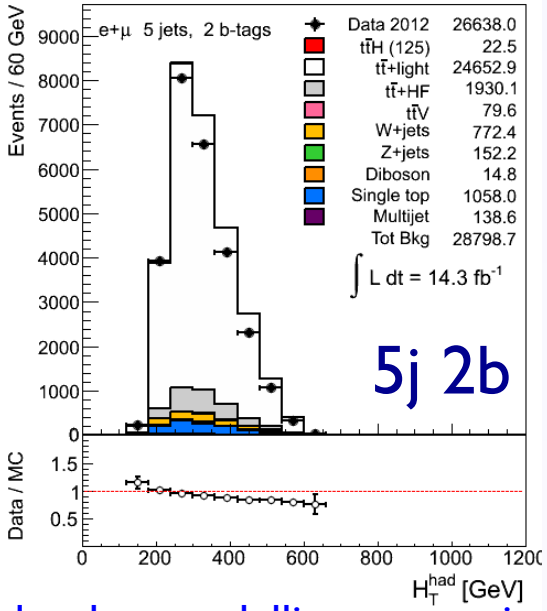
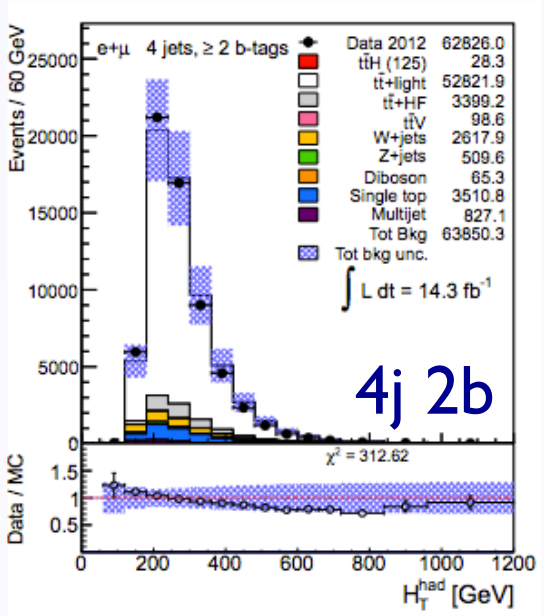
On behalf of the HSG5 ttH group

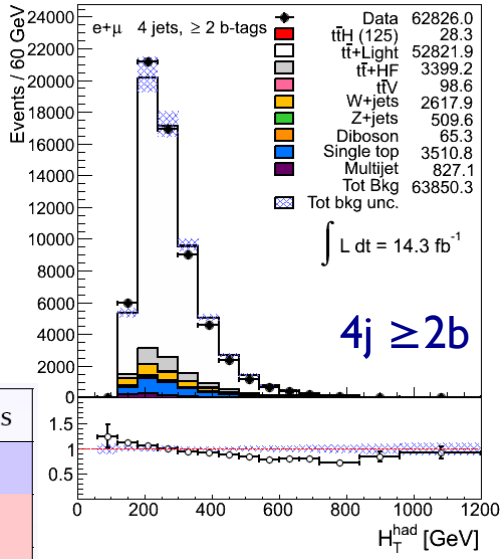
The issue

- ttH analysis for Moriond is performed using two options
  - single variable fit (exactly same approach as used in the approved CONF note)
    - HT and m_{bb} variables
  - fit to NN discriminant in signal bins and HT in other bins
- For both approaches good modelling of data by MC model is critical
- We observe slopes in data/MC ratio in all analysis bins with at least one tag

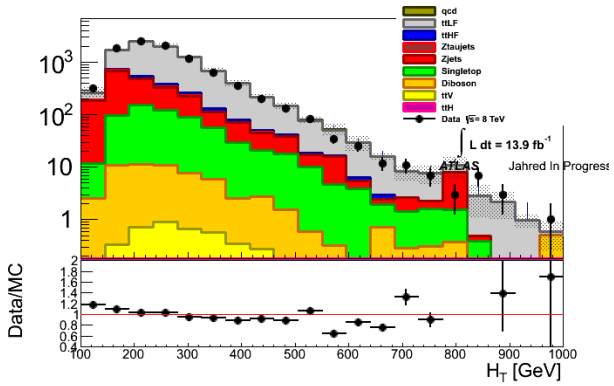




only ttbar modelling uncertainties



≥2j
≥1b



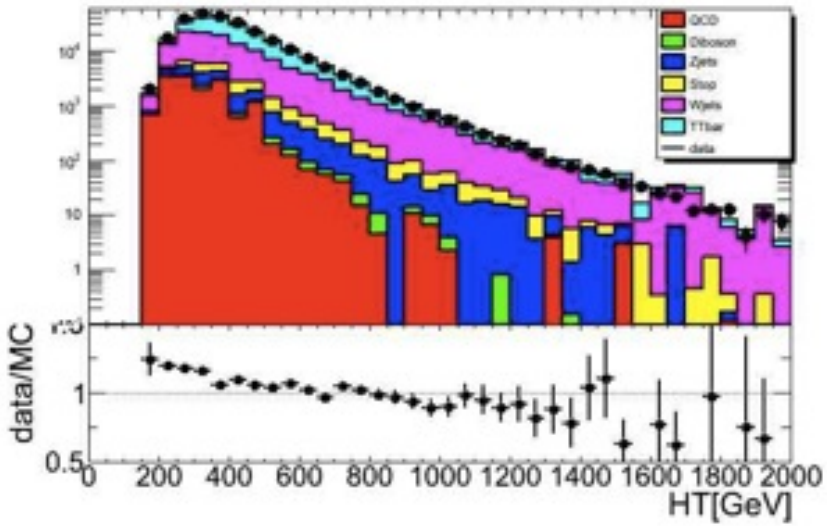
Same trend in dilepton channel!

	0 b-tag	1 b-tag	2 b-tags	3 b-tags	≥ 4 b-tags
4 jets	H_T^{had}	H_T^{had}	H_T^{had}		
5 jets	H_T^{had}	H_T^{had}	H_T^{had}	H_T^{had}	H_T^{had}
≥ 6 jets	H_T^{had}	H_T^{had}	H_T^{had}	$m_{b\bar{b}}$	$m_{b\bar{b}}$

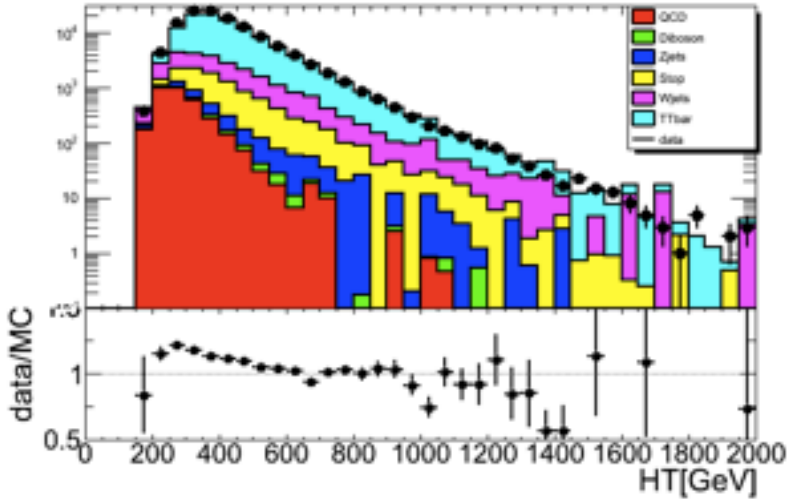
Other top analysis

4j+5j

≥0 b



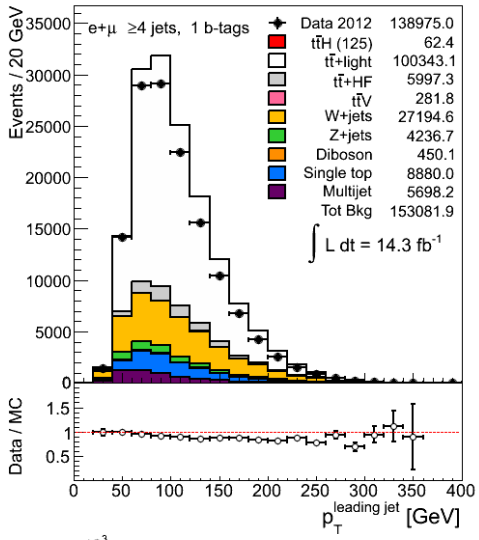
≥ 1b

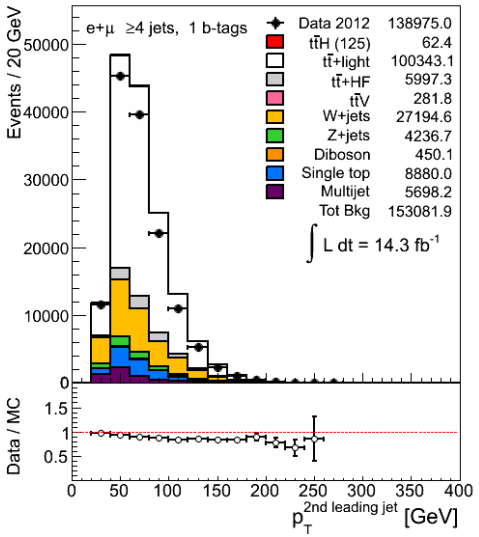


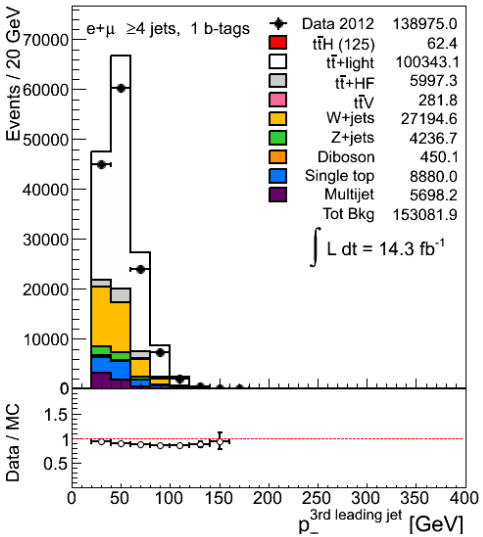
- the first plot produced outside ttH group
  - uses the same TopRootCore package
- similar trend
  - could be a problem in TopRootCore, but at least this shows it's not just a bug in our code

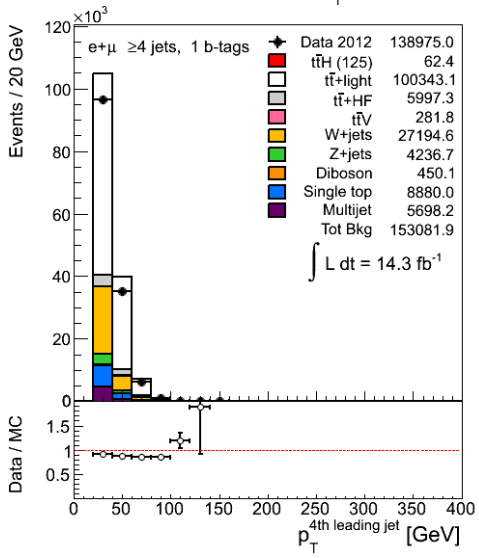
More distributions

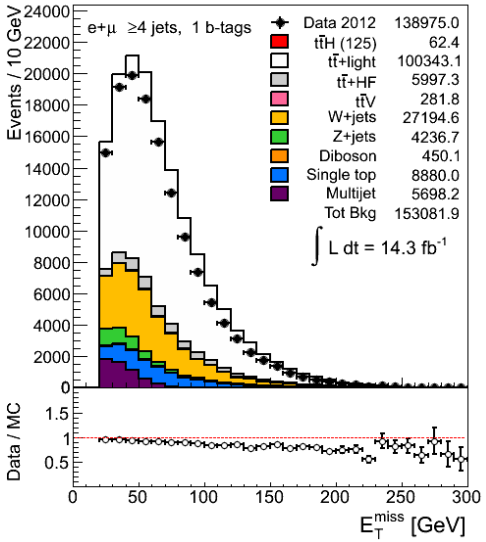
- Mismodelling of HT comes from mismodelling of jet PTs and ηs

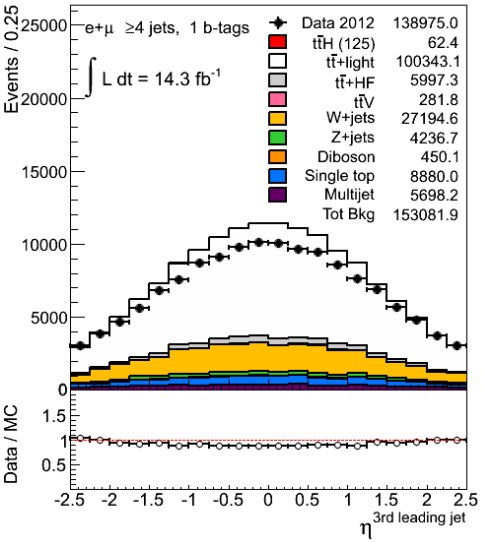












4j1b

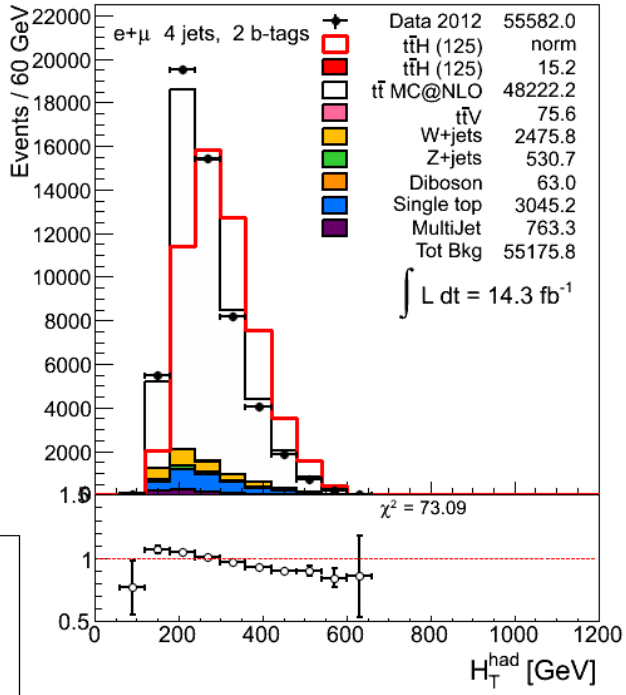
Same features are observed in other jet and tag multiplicity bins

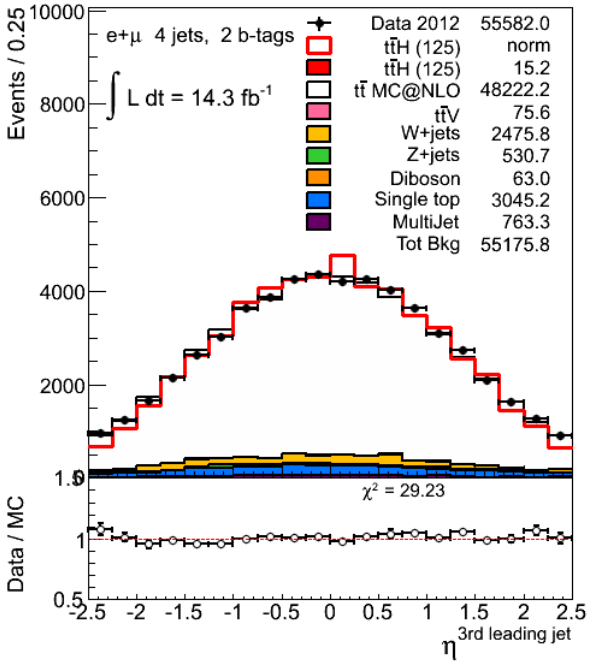
What is it?

- ttbar modelling
- pileup modelling
- effect of various scale factors
  - b-tagging (we are using pTrel calibration)
  - JVF
- test of b-tagging SFs
  - try SFs from ttbar calibration
- p_T^W reweighting
  - Top W reweighting?
- do we see this somewhere else? VH cuts
- multiparton interactions?
- jets - JES?
  - tried EM+JES instead of the default LC jets

ttbar modelling - I

- Given that the problem is seen in ttbar dominated regions we suspected ttbar modelling
- Default: Alpgen+Herwig
- Tried
  - MC@NLO
  - Powheg+Herwig (AFII)
  - Powheg+Pythia (AFII)

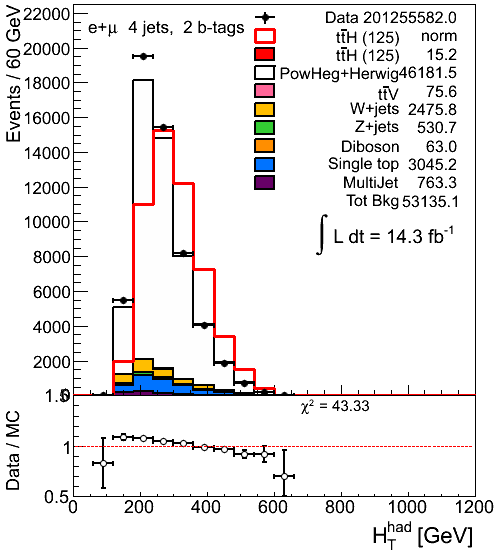


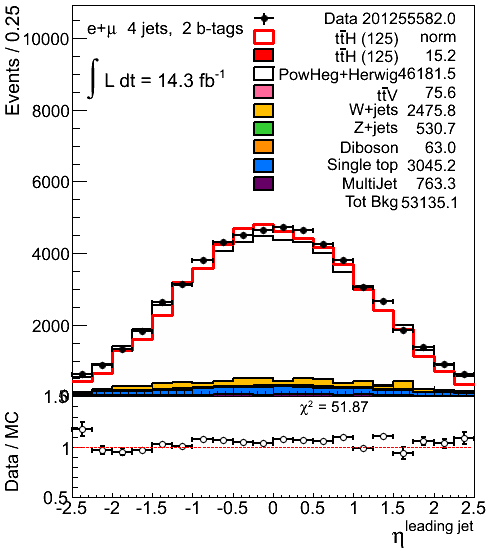


MC@NLO
- same slope in HT
- jet η looks better

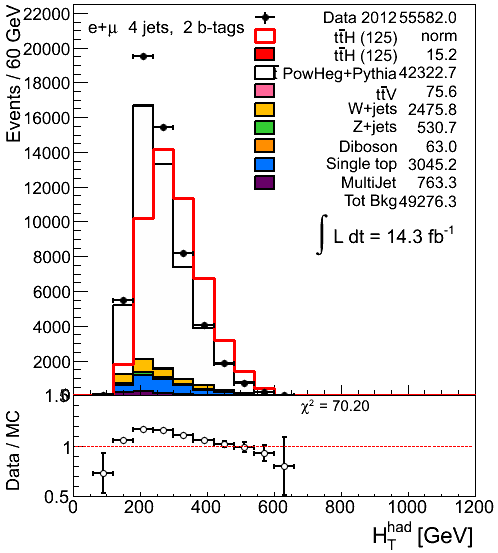
ttbar modelling - II

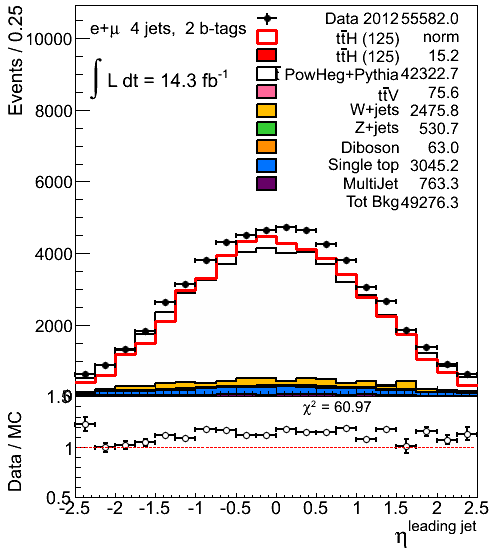
Powheg+Herwig



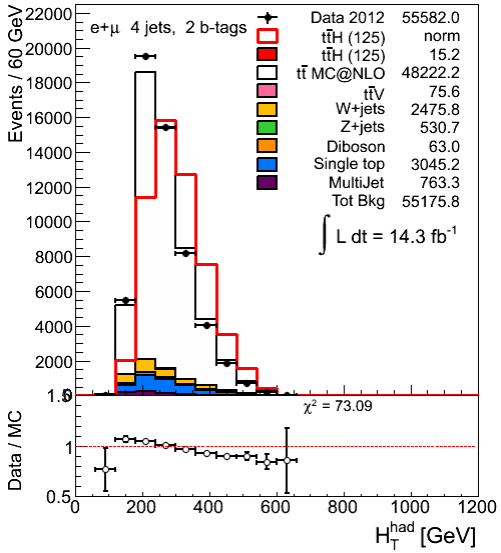


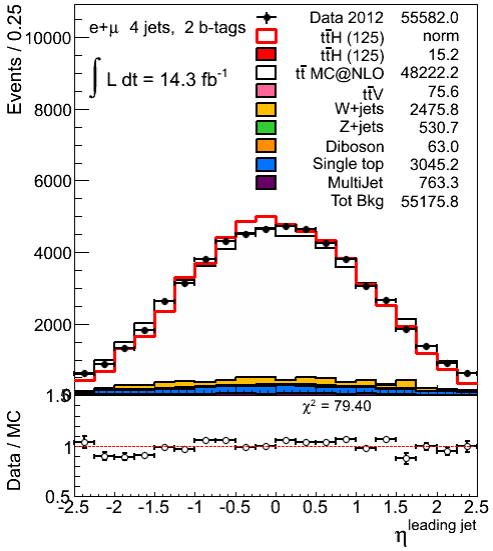
Powheg+Pythia





MC@NLO

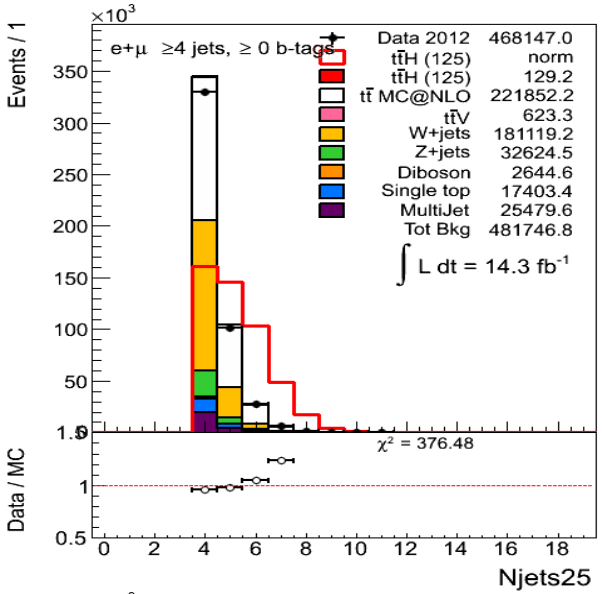


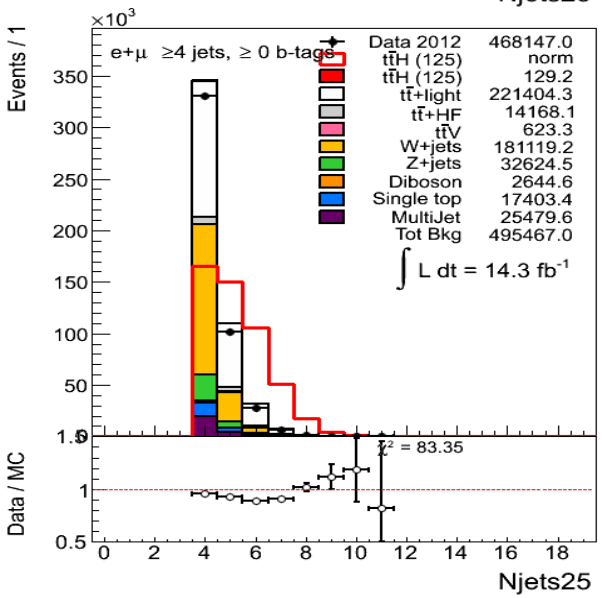


NLO MC describes jet η distribution better

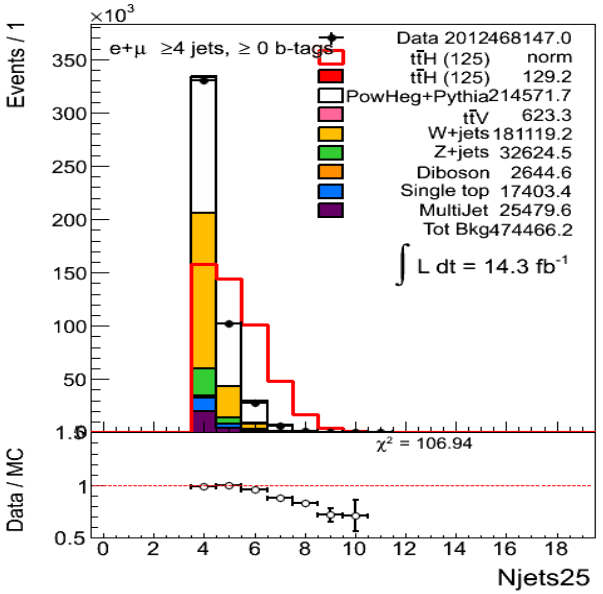
Jet multiplicity

MC@NLO

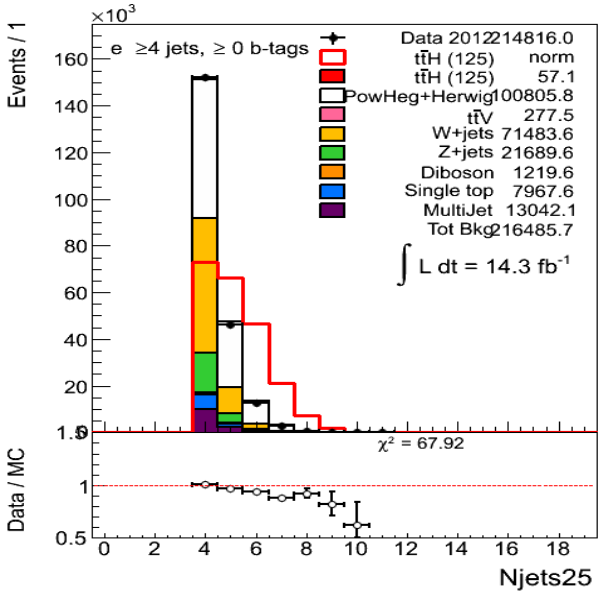




Powheg+Pythia



Powheg+Herwig



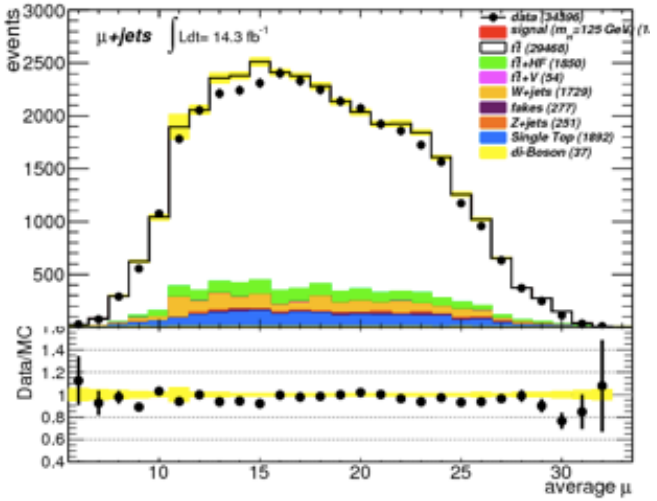
Alpgen+Herwig default

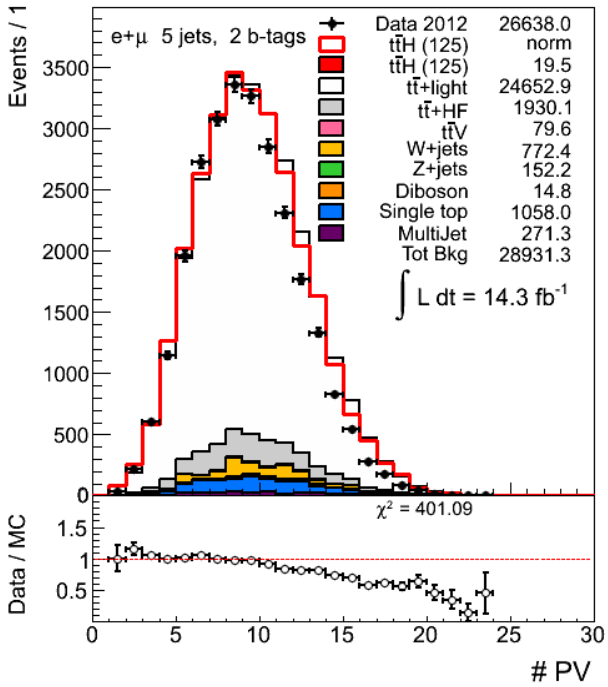
4 jets inclusive pretag

Pileup

- We perform luminosity reweighting following recommendations but the NPV distribution in data is not well described
- MC overestimates NPV in data
- However the twiki says that agreement in NPV is not expected to be perfect even after μ reweighting

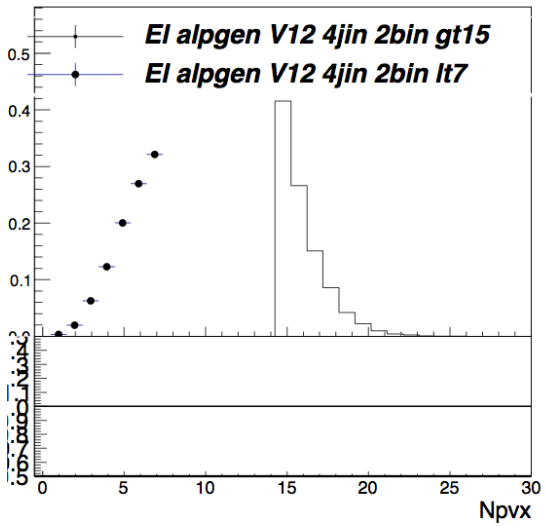
https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/InDetTrackingPerformanceGuidelines#Analyses_based_on_Athena_release

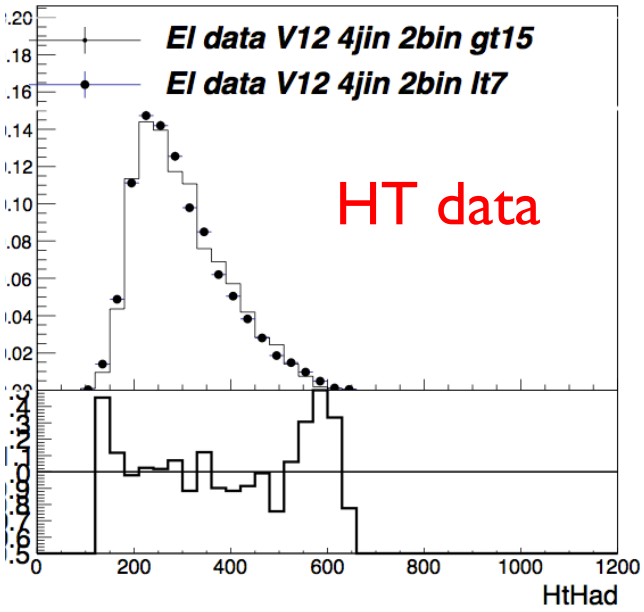


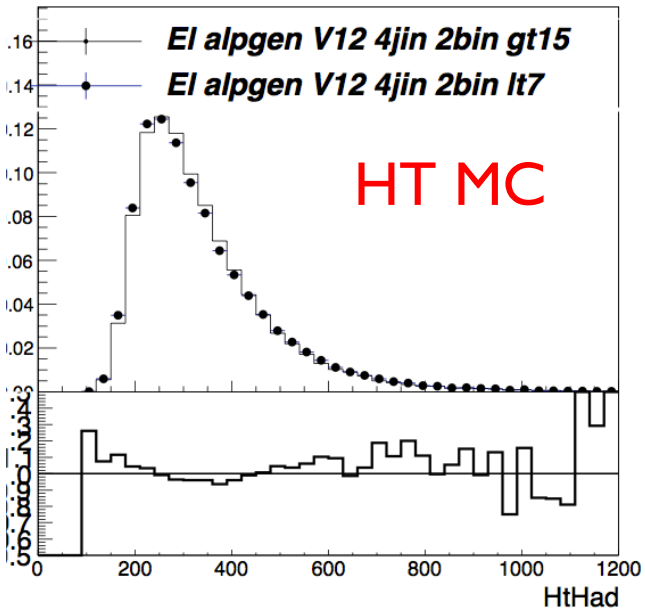


NPV<7 vs NPV>15

- e+jets, 4 jet incl 2b incl



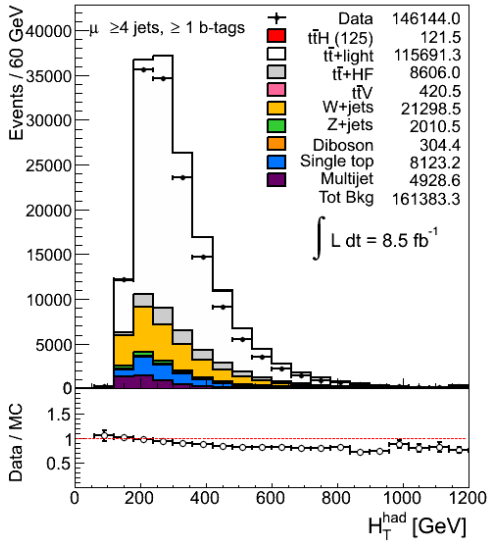




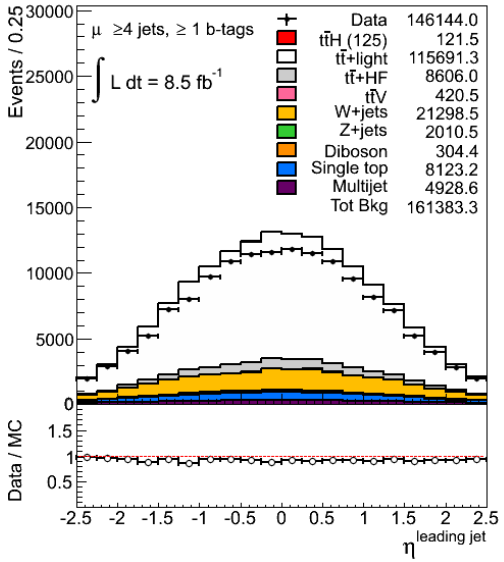
- NPV<7 - points, NPV>15 - histogram
- shape does not change significantly between low and high NPV
- trend in MC follows trend in data
- does not seem to explain the problem

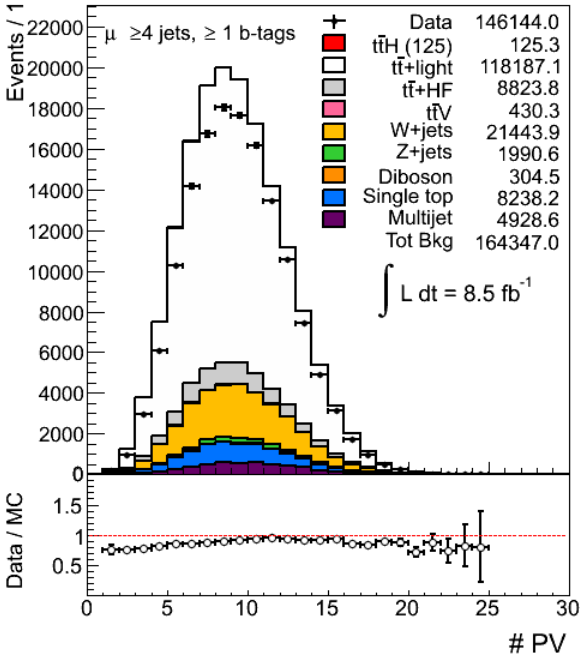
NPV reweighting

- Although effect is expected to be small let's reweight NPV to match data better



before NPV reweighting

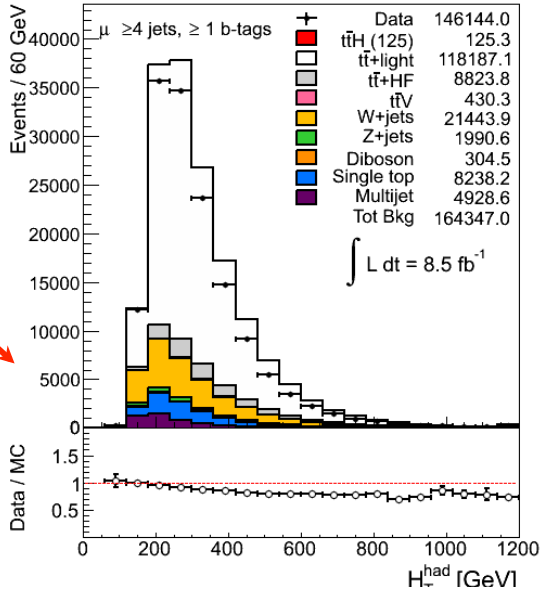


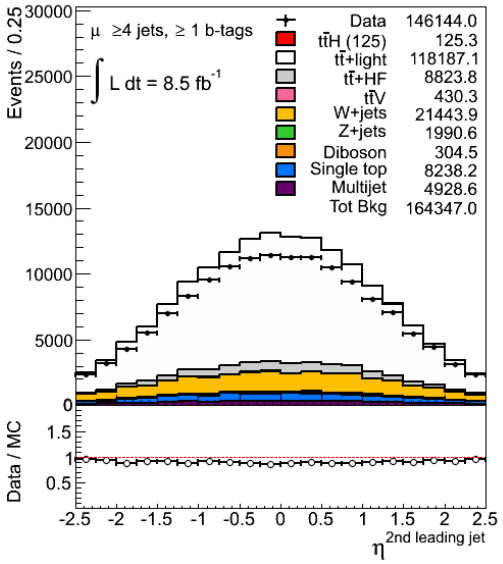


reweighted in 2j inclusive

does not help!

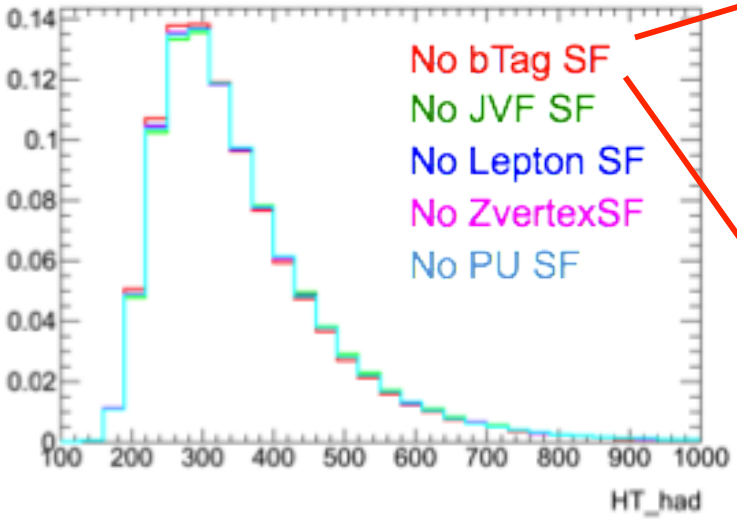
after NPV reweighting

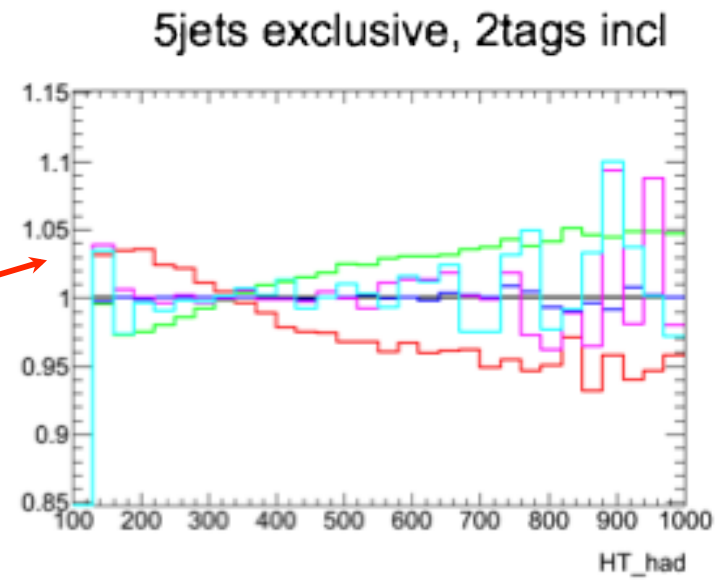


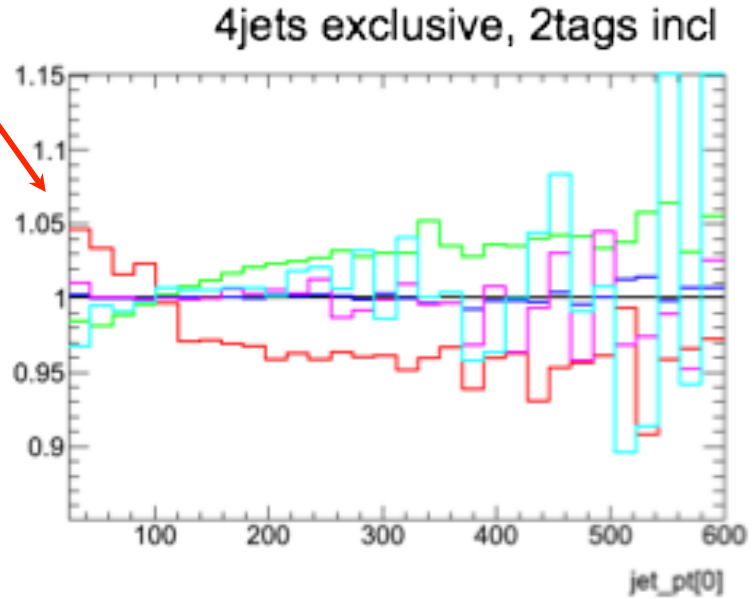


Impact of SFs on HT shape

- remove various SFs one by one and look at the effect on HT shape
- study on ttbar MC
  - tt+light and tt+HF



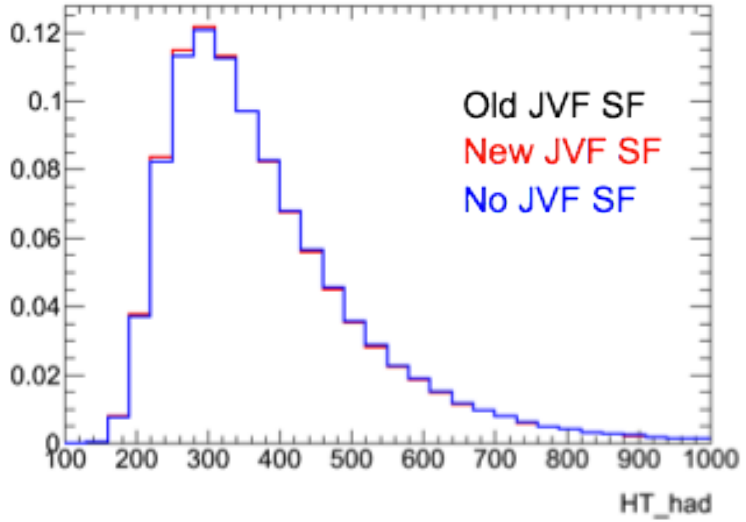


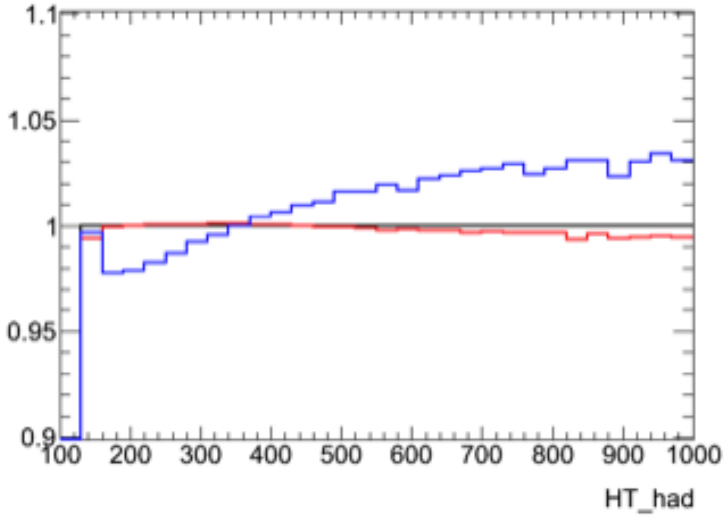


- removing bTag SF: this seems to have a pretty large impact and goes in the direction we would like (increasing low side, decreasing high side)
- bTag SF: largest effect on nuisance parameters in the fit

JVF SF

- We use "old" JVF SF derived for EMJES jets
- In the meantime new JVF SFs were announced
  - derived for LC jets!
- blue: no scale factor
- red: new JVF SF
  - effect seems to be small but it goes in the right direction
- black: old JVF SF

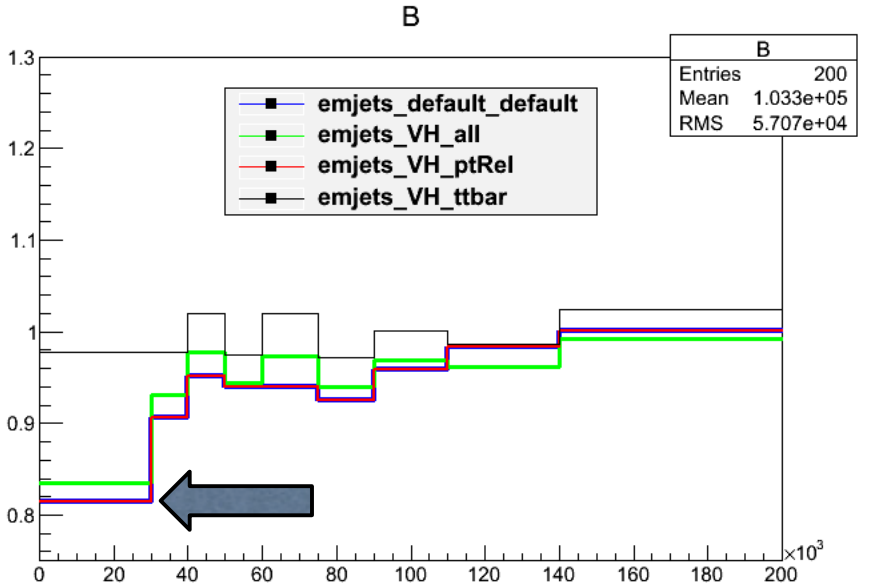


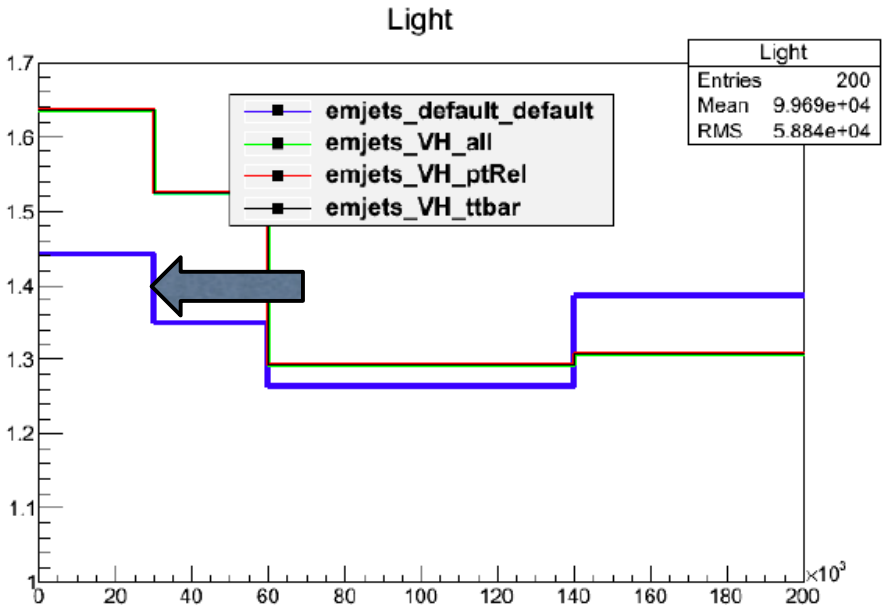


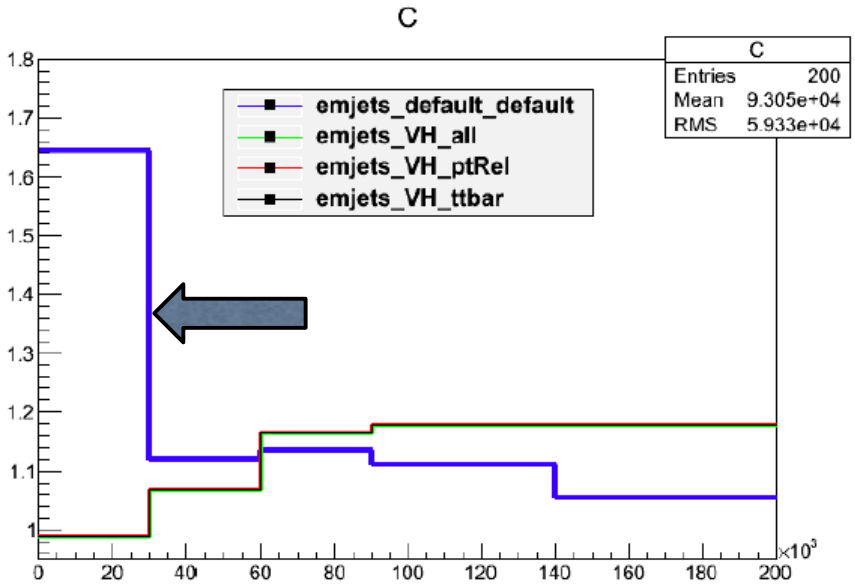
5jets exclusive, 2tags inclusive

Study of b-tagging

- So far using 2011 pTrel calibration
- Need to get HCP recommended file:
  - 2011+2012(a) pTrel calibration
  - 2011 ttbar calibration
- Note:
  - VH_ptrel is the one we are using
  - We don't understand what the c and light calibrations are showing



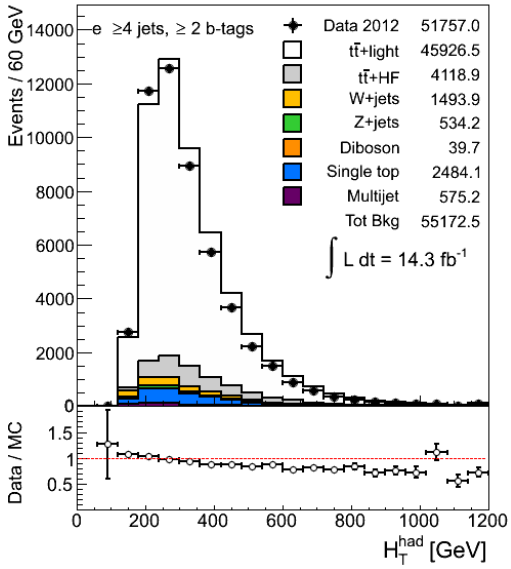


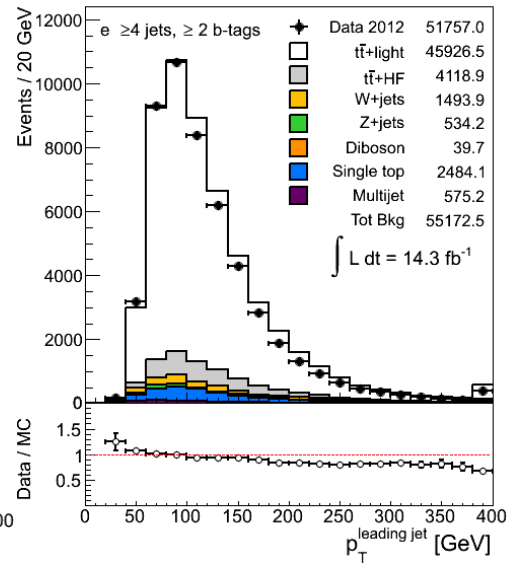


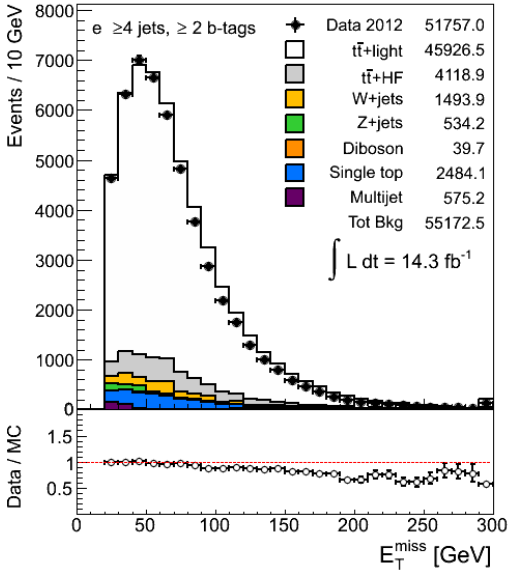
Comparison: ttbar control region

- Electron channel, 4jet inclusive, 2tag inclusive

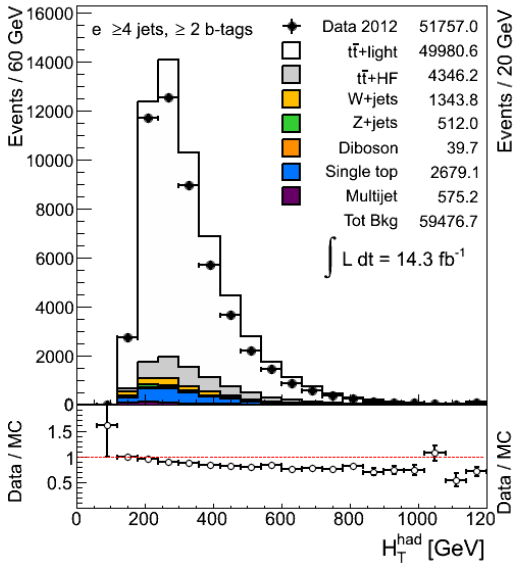
PtRel calibration

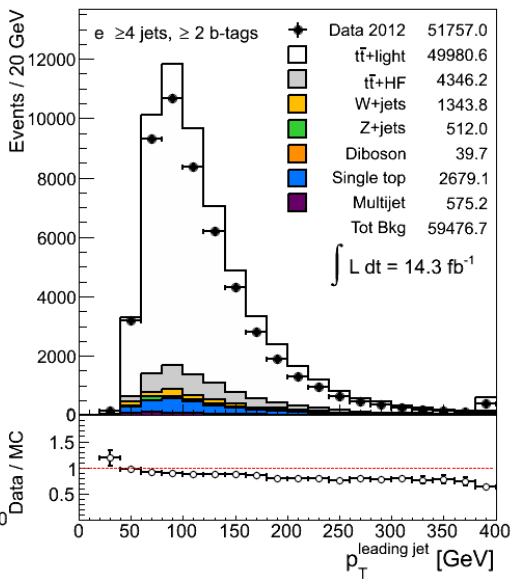


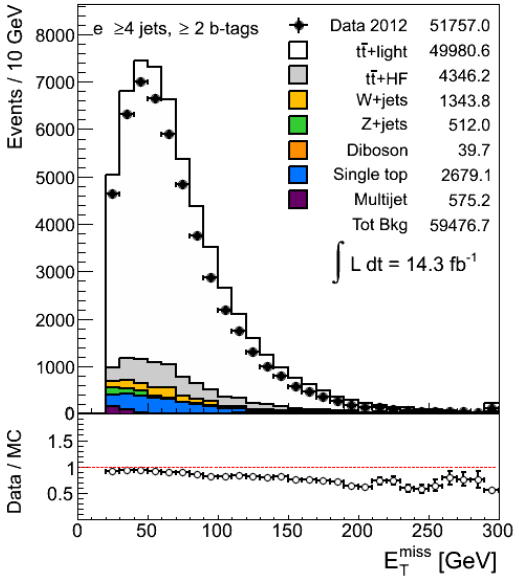




ttbar calibration

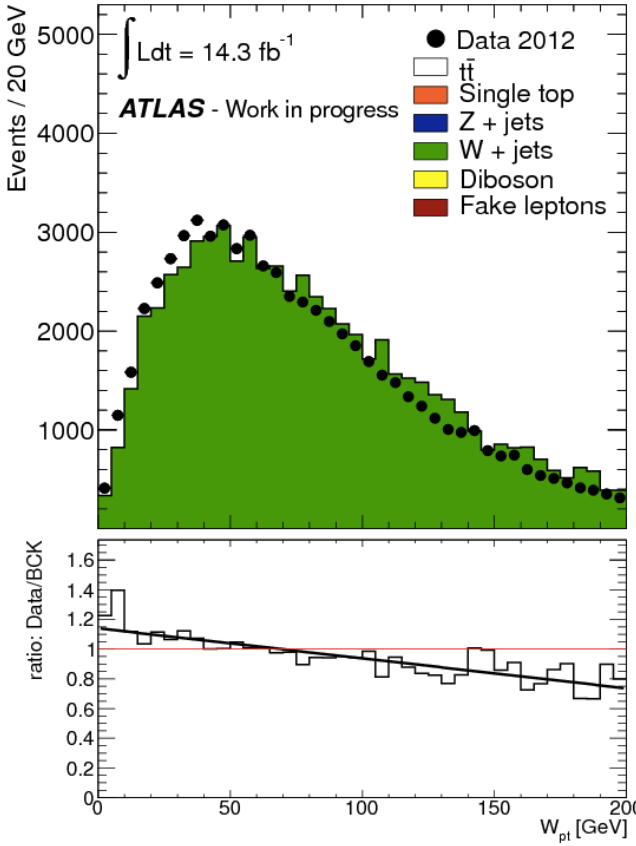


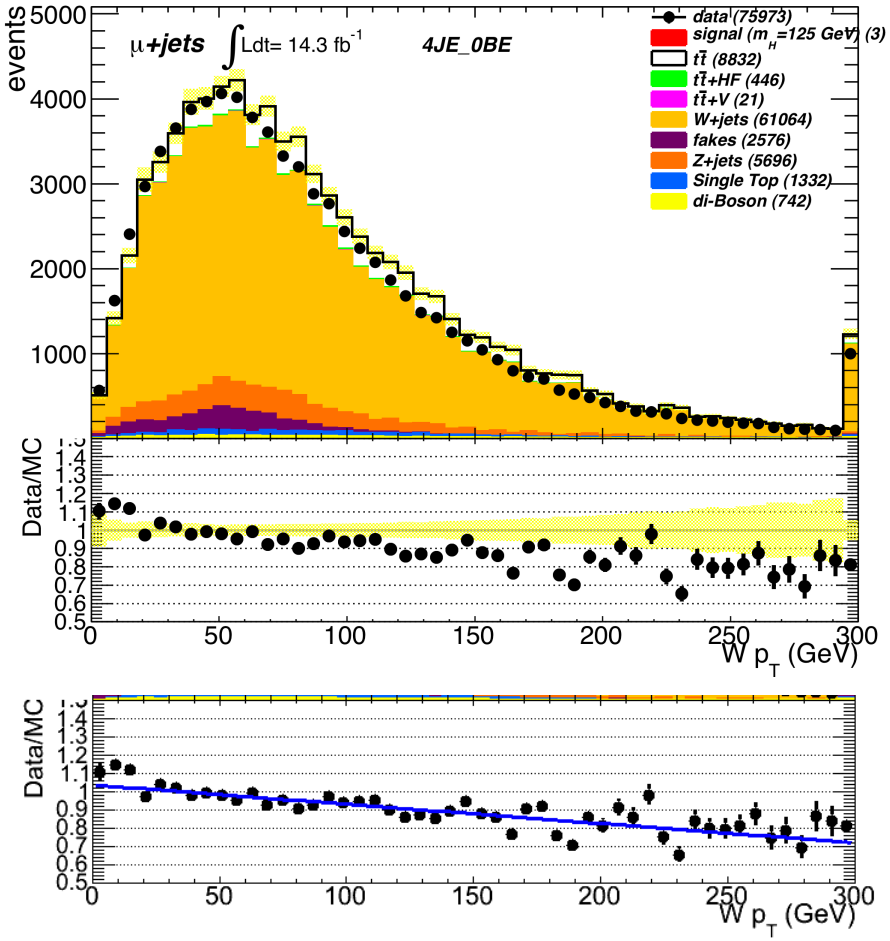




p_T^W reweighting

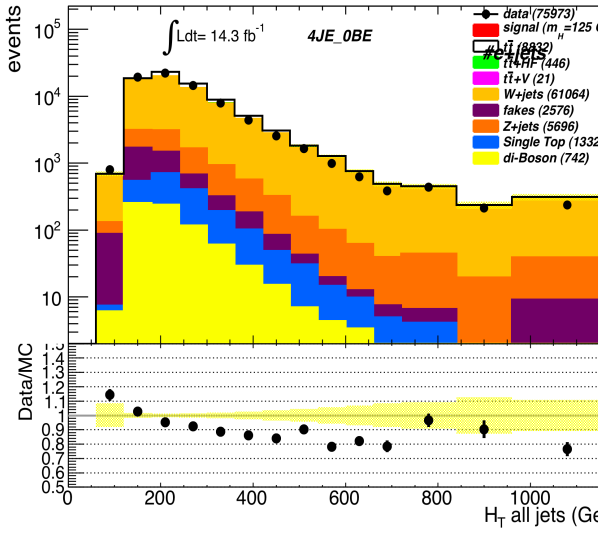
- 4 jet (exclusive) no b-tags
- Reweight p_T^W as done by VH analysis for HCP

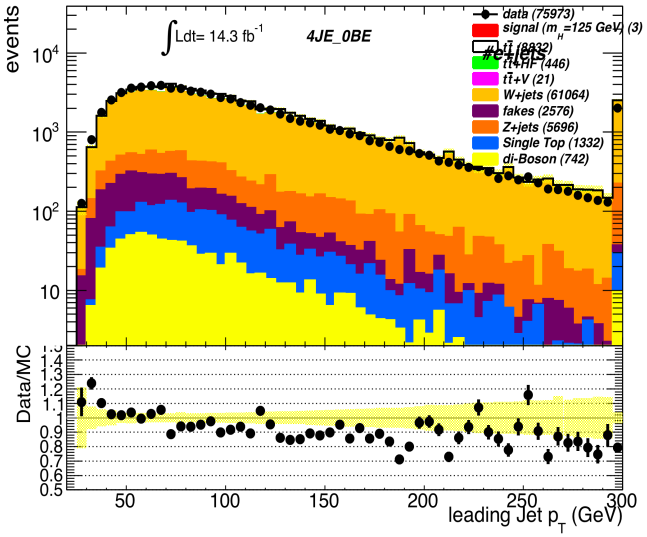


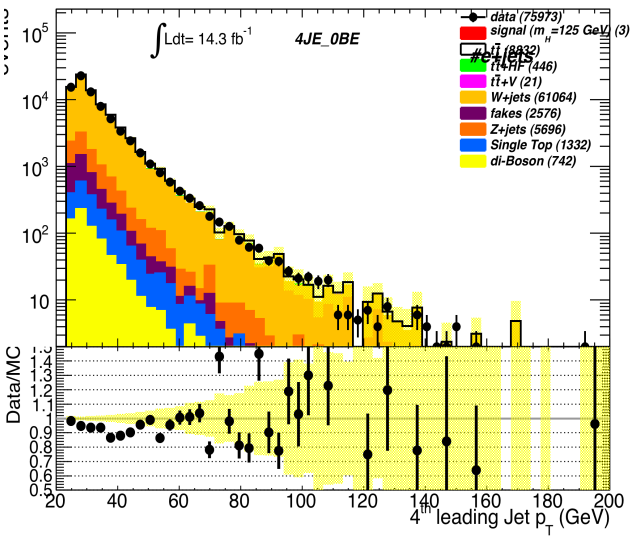


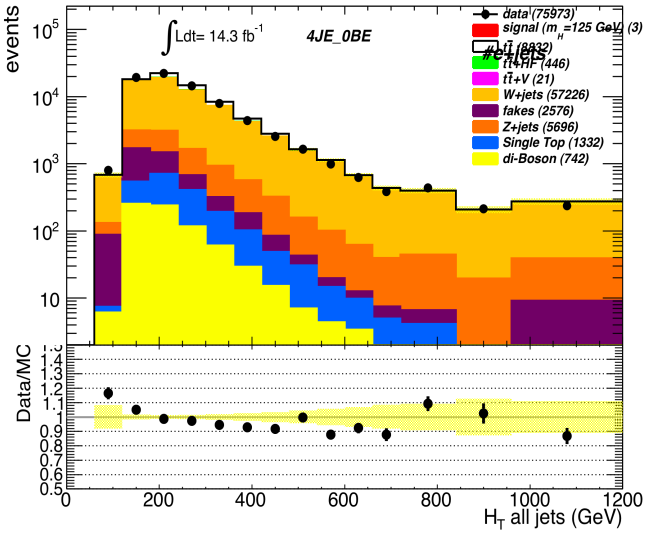
Minimizer is Linear
Chi2 = 130.962
NDf = 38
p0 = 1.126 +/- 0.01
p1 = -0.0020 +/- 0.0001

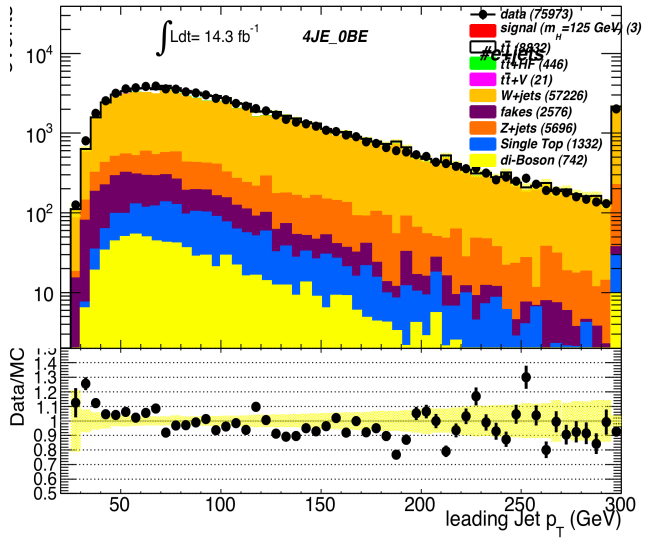
No reweight (up) , reweight (down)

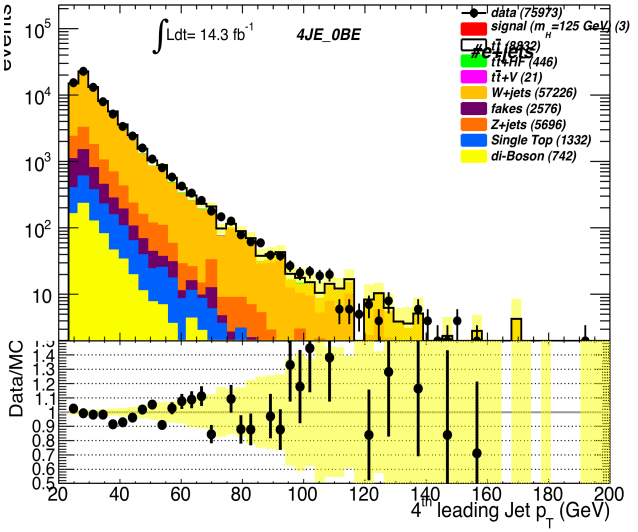






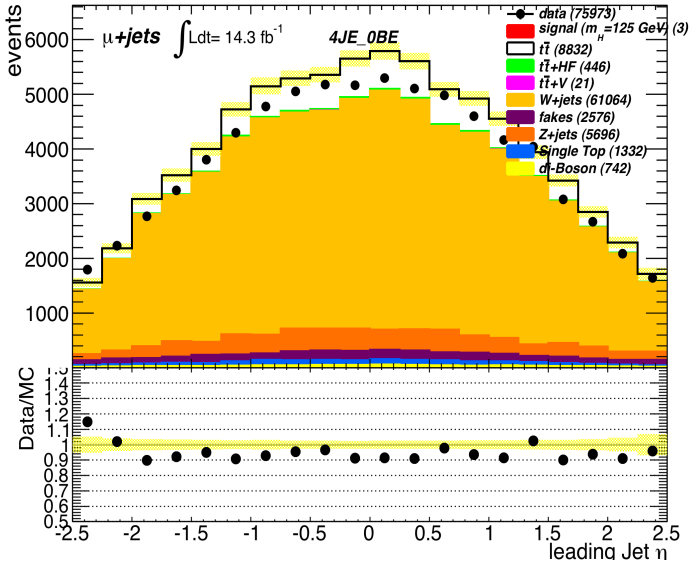


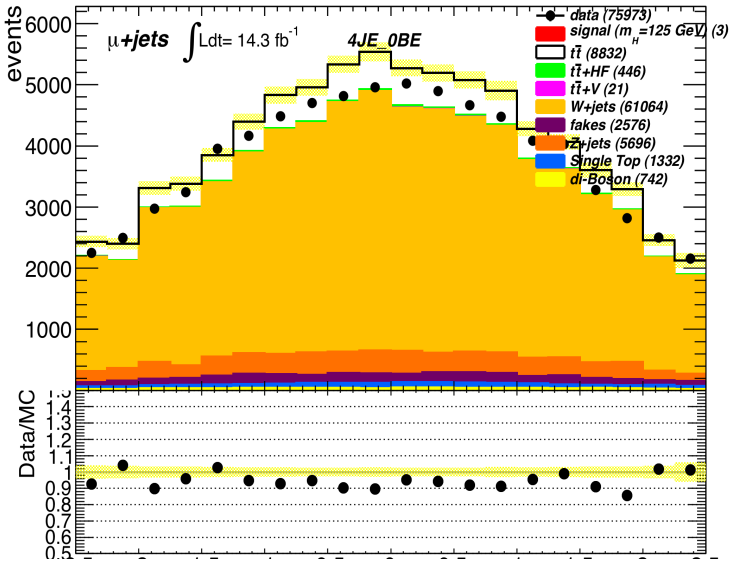


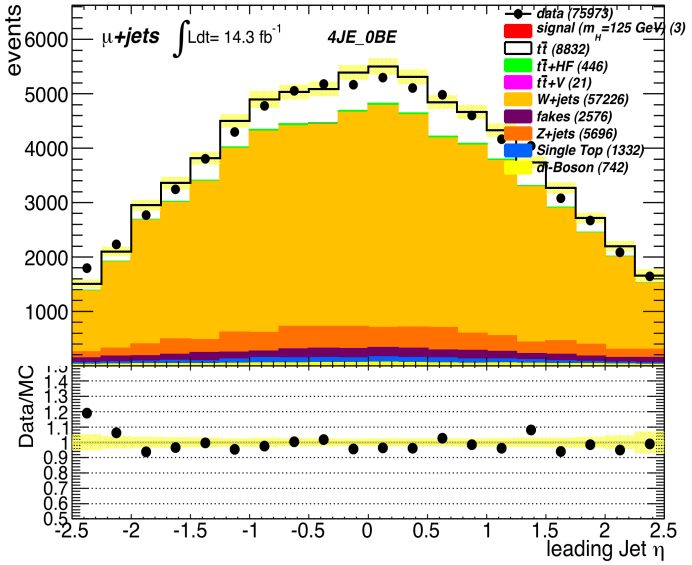


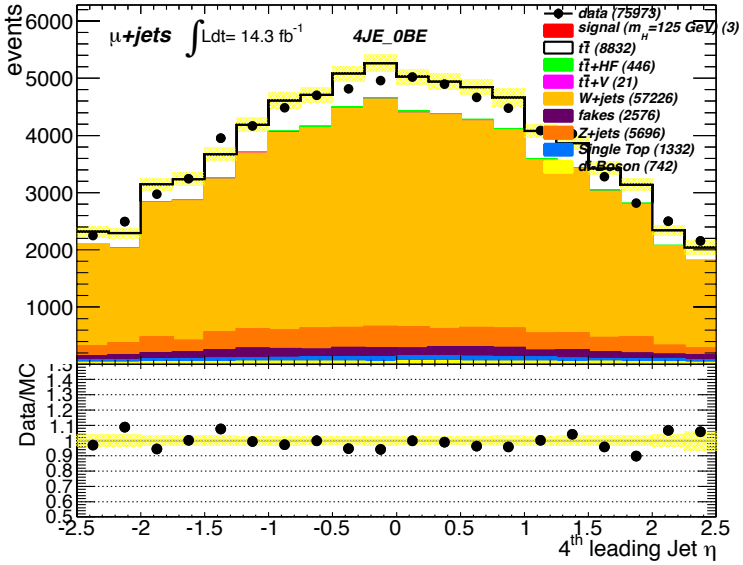
- Some improvement but features are still there

No reweight (up) , reweight (down)





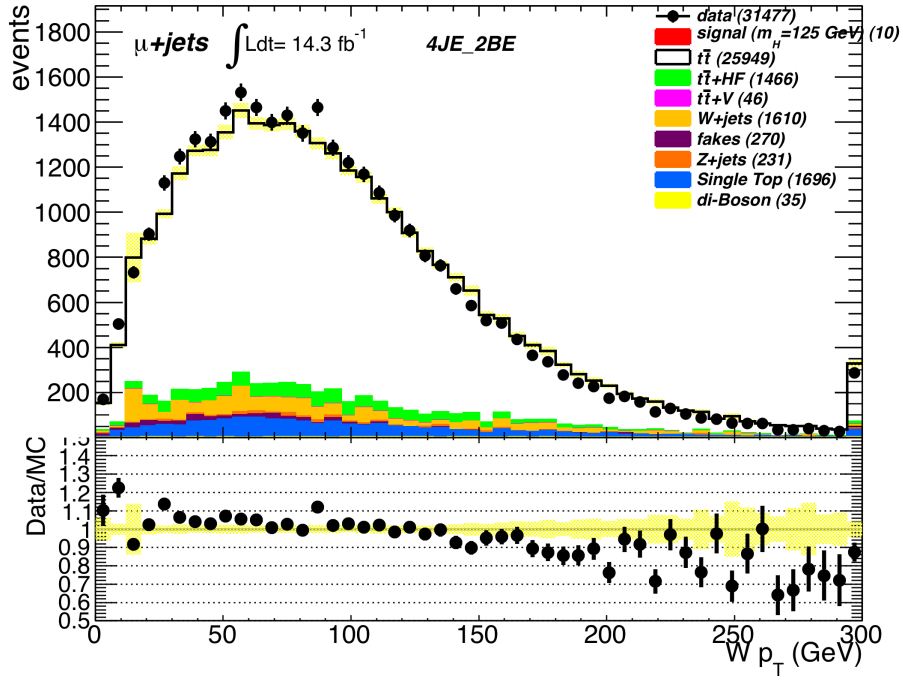




- Improvement in Jet eta …

Ttbar reweighting?

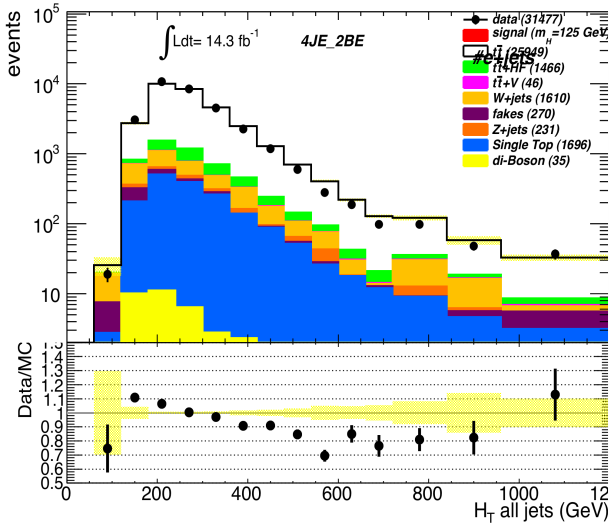
- In progress… we want to test it to see what we get
- BUT not clear we should do it when we use the modeling nuisance parameters from Alpgen

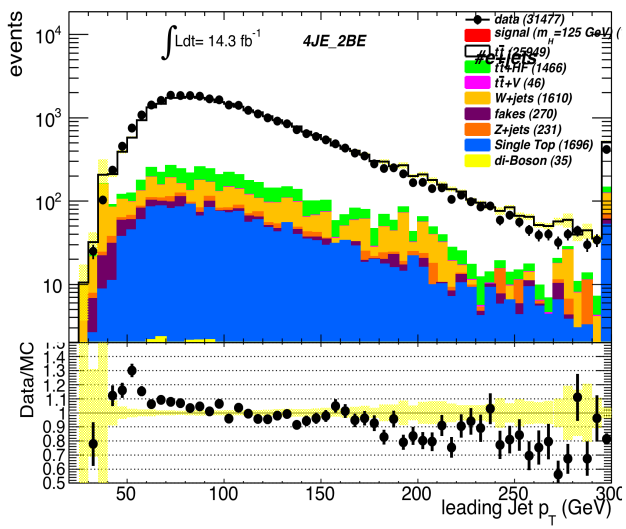


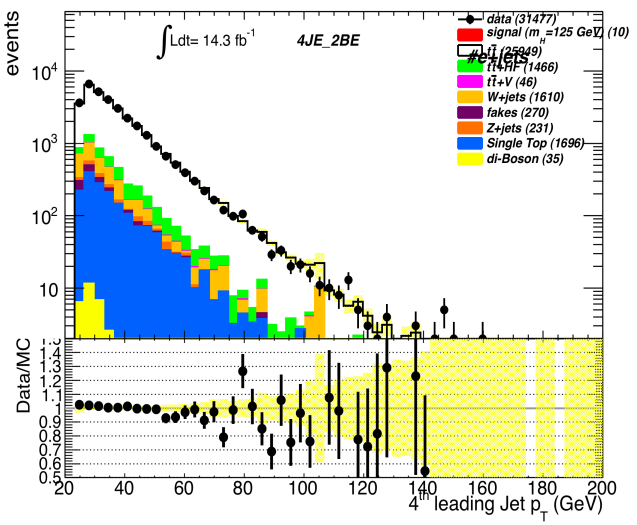
Do we see this with VH cuts?

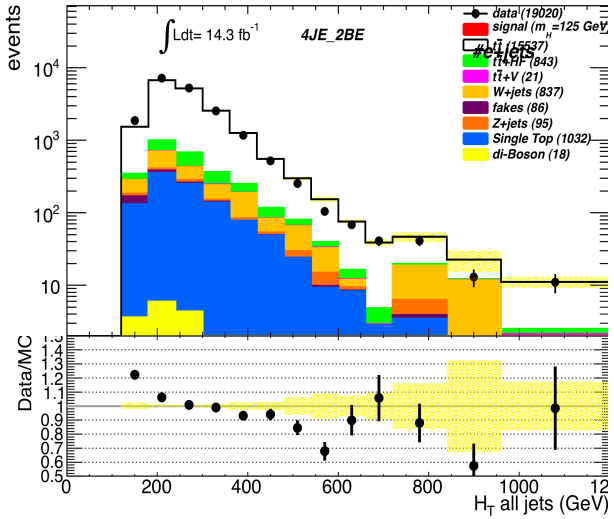
ttH cuts (top)/ VH cuts (bottom)

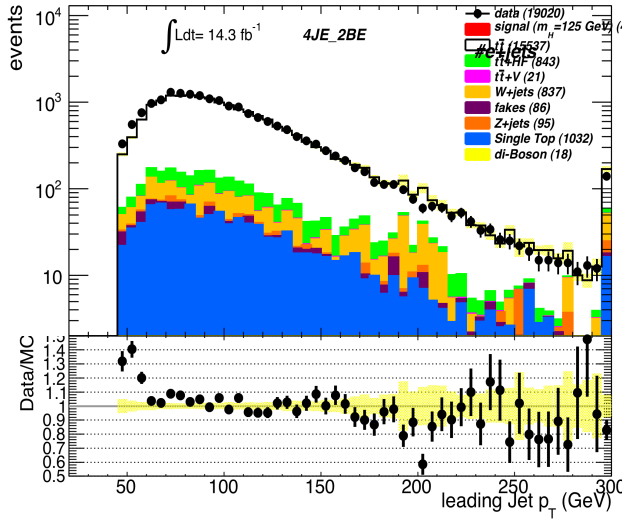
pT bin	0-60	60-120	120-160	160-200	>200
MET	>25	>25	>25	>25	>50
MTW	>40	>40	>40	-	-
MTW	<120	<120	<120	<120	<120
DeltaR(b.b)	>0.7	>0.7	>0.7	>0.7	-
DeltaR(b,b)	-	-	< 1.9	<1.7	<1.5

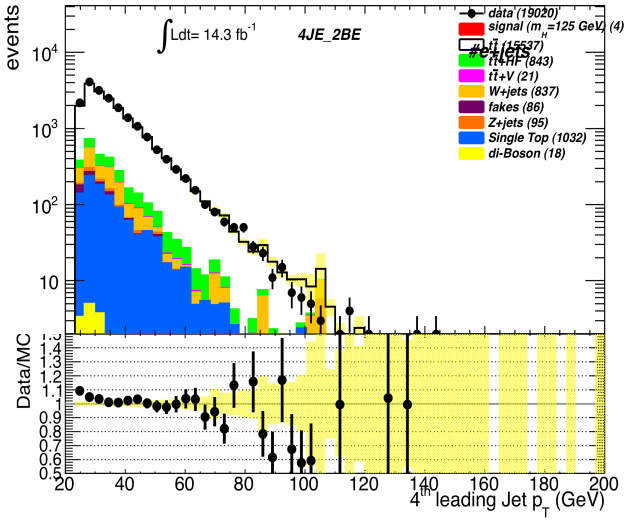






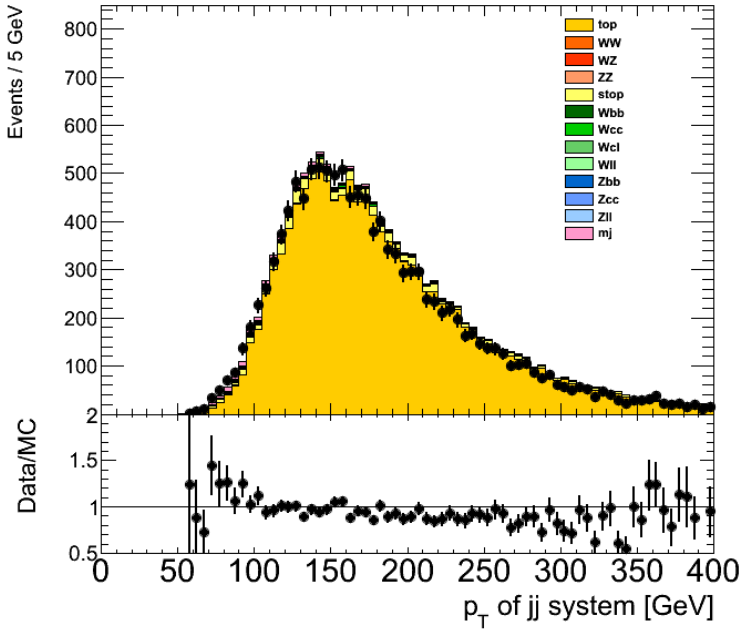


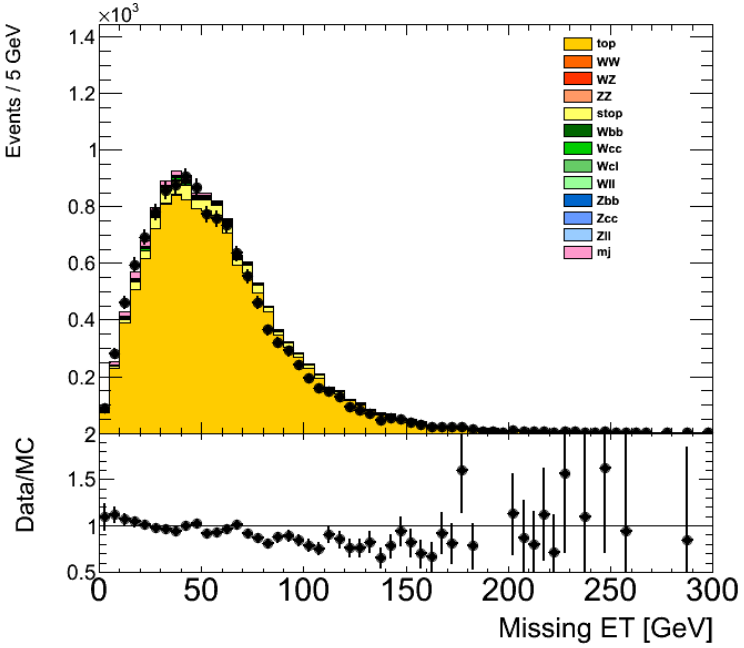


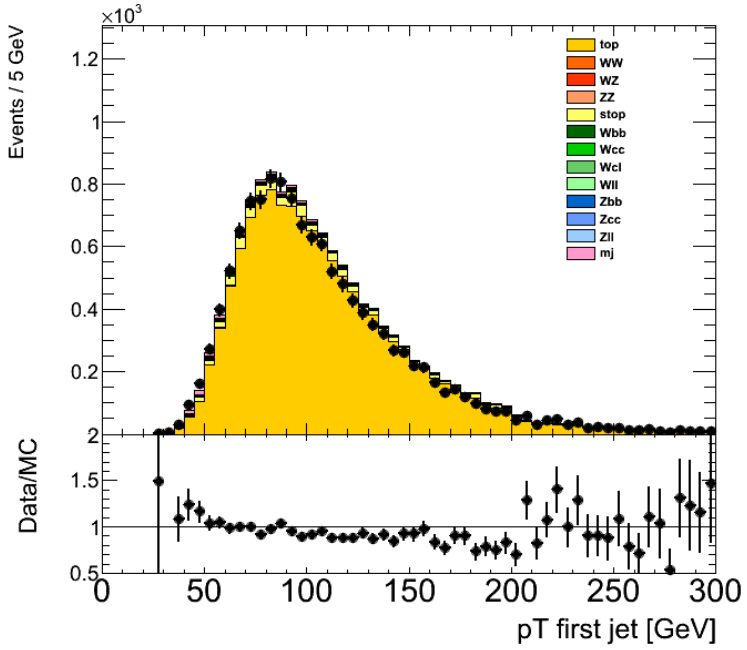


- Can't tell if it's really better (low jet pt can be QCD)

Do we see this with VH cuts?







VH analysis ~ with ttH cuts:

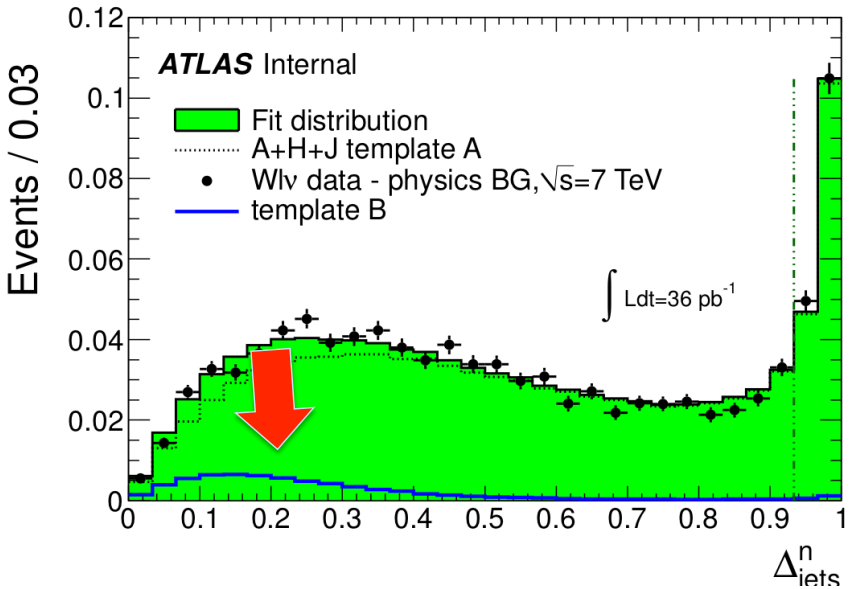
≥ 4jets and ≥ 2 b-tags

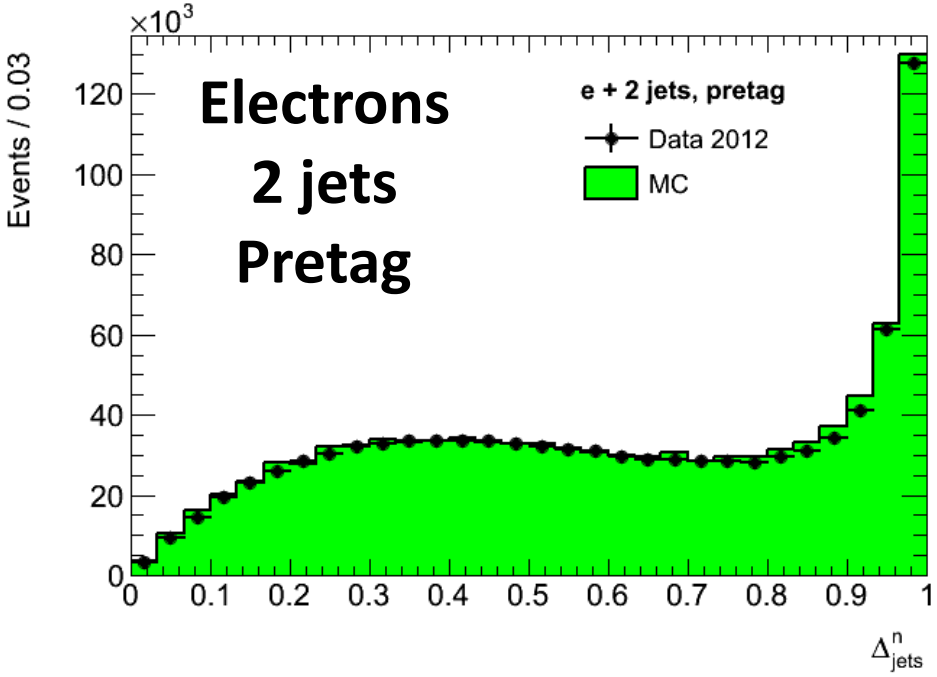
No p_T^W reweighting applied

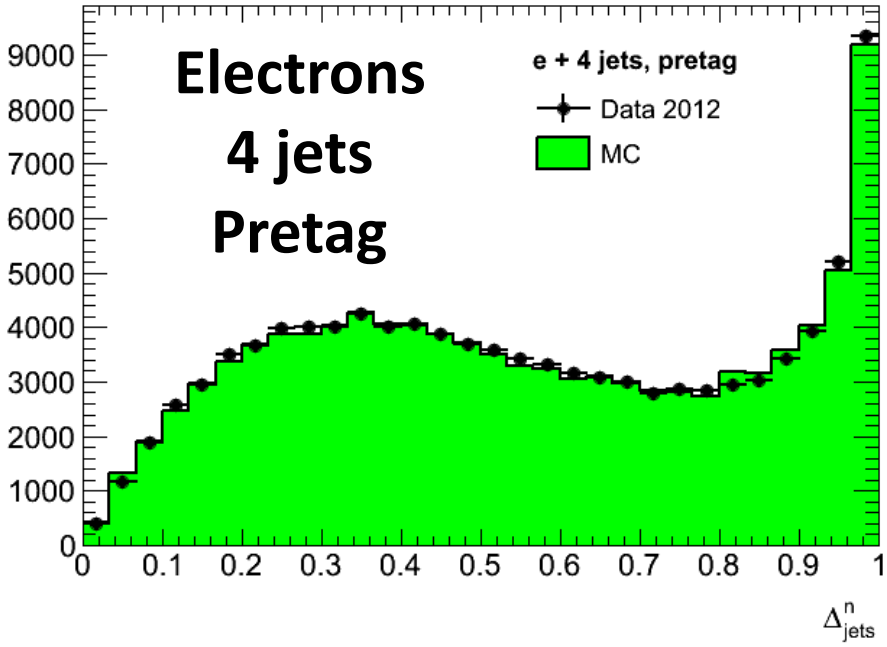
MultiParton Interaction Study

STDM-2012-11: http://cdsweb.cern.ch/record/1456092

- Two independent scattering
- 2 parton pairs: W, dijet.
- $\Delta_{jets}=|\mathbf{p}_{T1}-\mathbf{p}_{T2}|/|\mathbf{p}_{T1}|+|\mathbf{p}_{T2}|$
- JES ≈cancels, should be 0
- No indication of missing contribution in e+2jet.

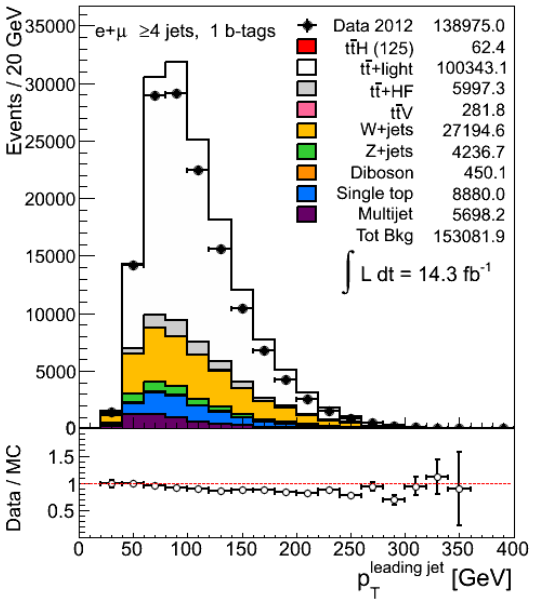


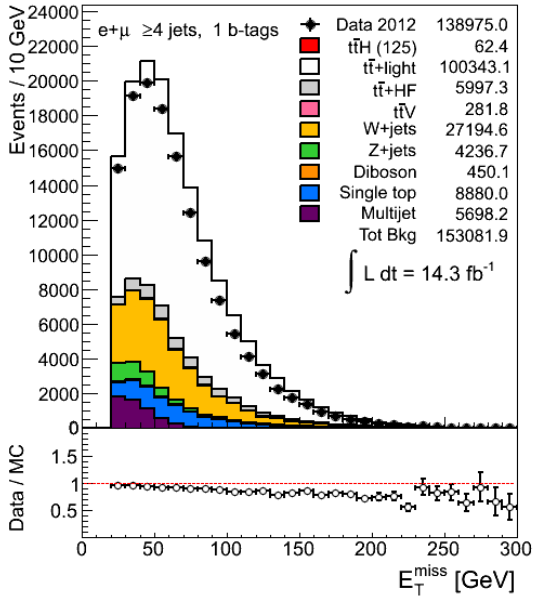


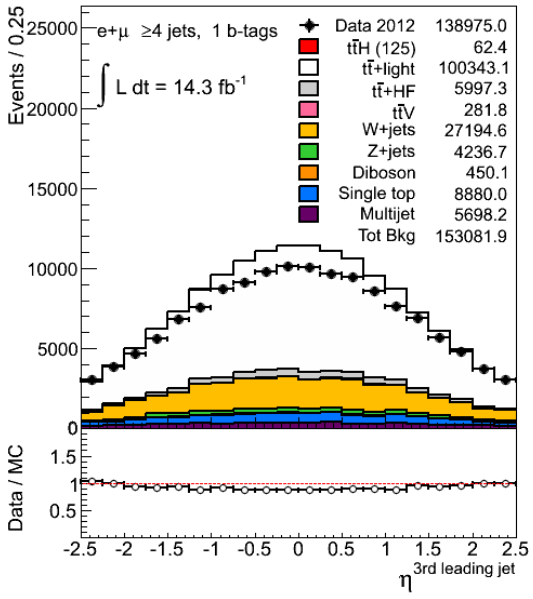


LC jets vs EM+JES

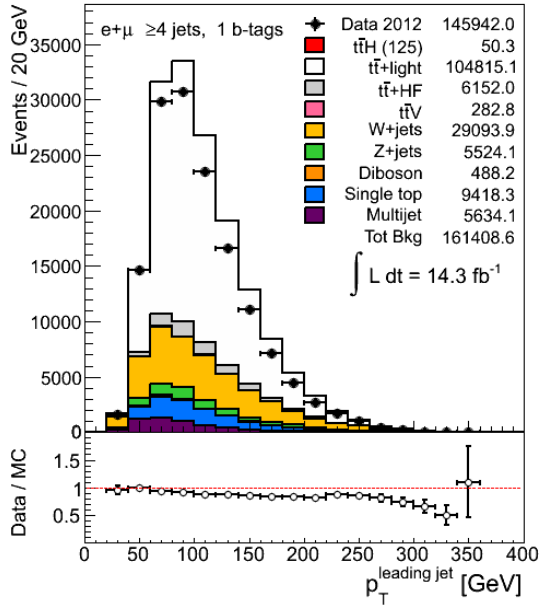
- EM+JES seem to give better description of data, but same features as LC

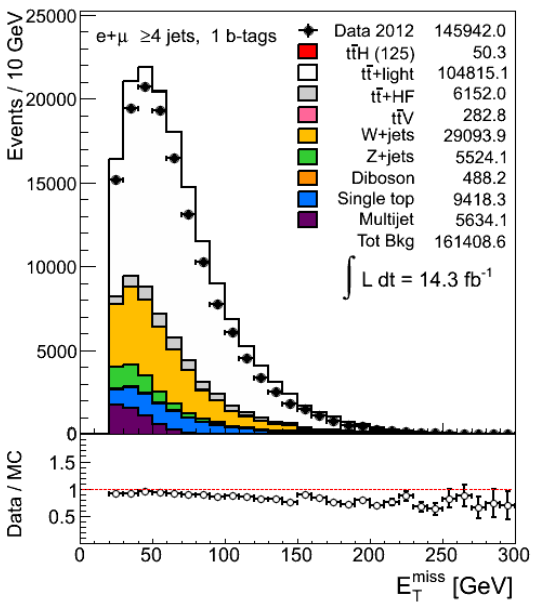


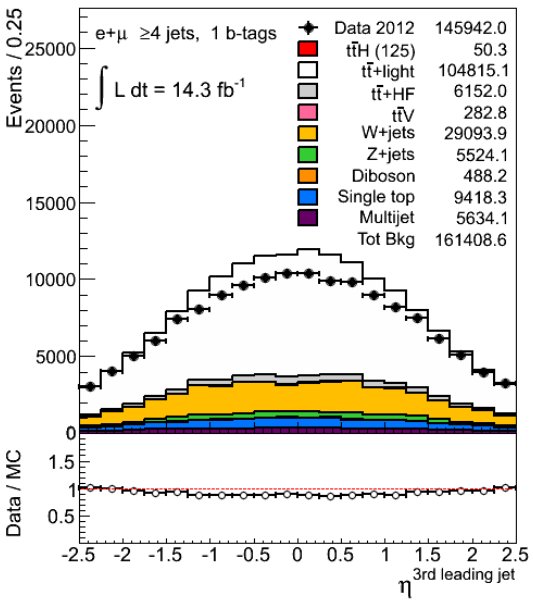




LC jets







EM+JES jets

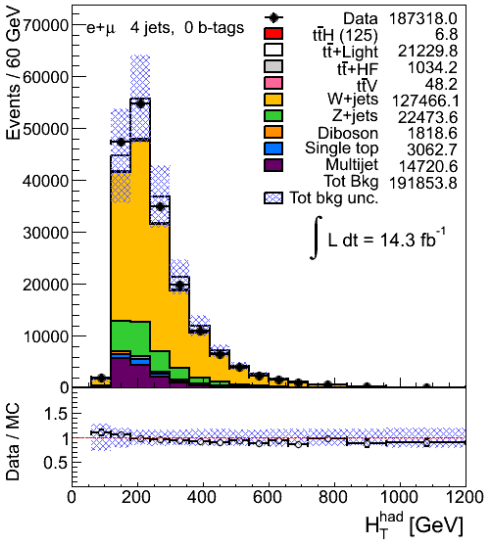
Latest Changes

- Switched from a theoretical uncertainty in W+4jets production (48%) to the experimental one given by the charge asymmetry normalization
- Implemented latest prescription (from 7TeV) for W+HF systematics, they should be uncorrelated against Njets
- All systematics are shape+normalization
  - For simplicity JVFSF and Xtag were normalization only for the small backgrounds
- Introduced ttbarHF systematic
- Introduced jet energy resolution
- Introduced the breakdown of JES into 8 components
- Rebinned the JES breakdown so that the relative error per bin is 2% or less
- Corrected a discrepancy in electron QCD in the forward region for 0tag
- Rescaled the MC for the missing luminosity (-3% muon, -0.5% electron)

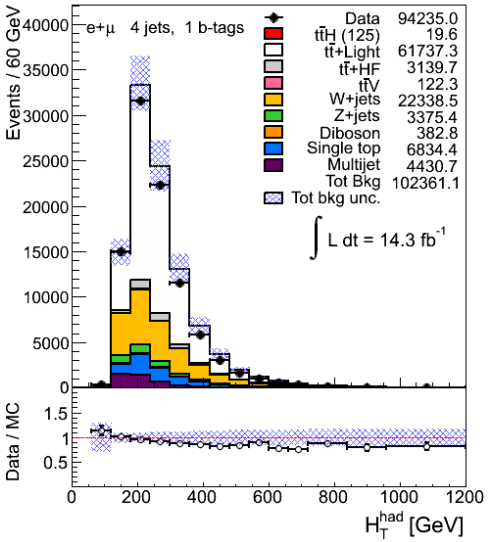
	0 b-tag	1 b-tag	2 b-tags	3 b-tags	$\geq$ 4 b-tags
4 jets	H_T^{had}	H_T^{had}	H_T^{had}		
5 jets	H_T^{had}	H_T^{had}	H_T^{had}	H_T^{had}	H_T^{had}
$\geq$ 6 jets	H_T^{had}	H_T^{had}	H_T^{had}	$m_{b\bar{b}}$	$m_{b\bar{b}}$

Pre/post fit plots

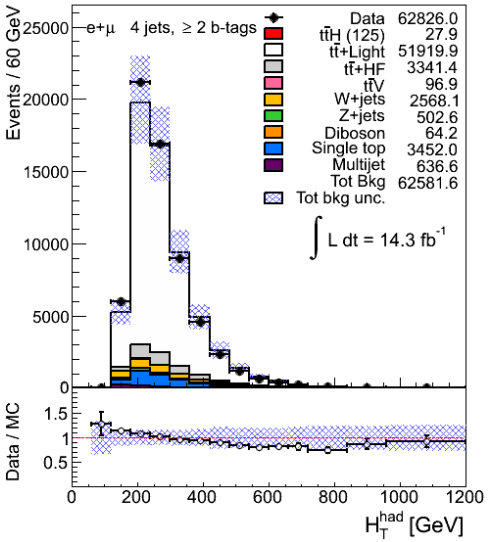
Prefit: 4jetex 0btagex



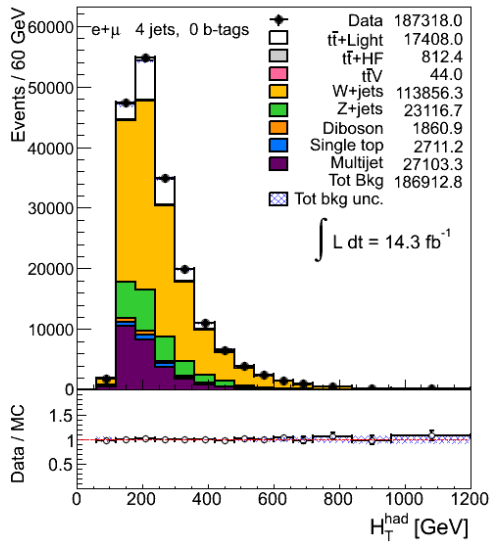
4jetex 1btagex



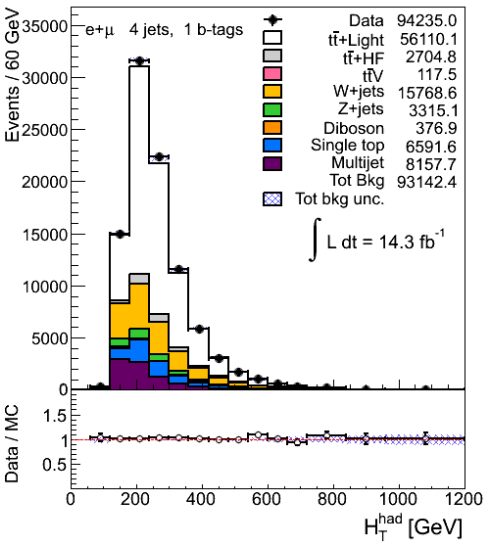
4jetex 2btagin



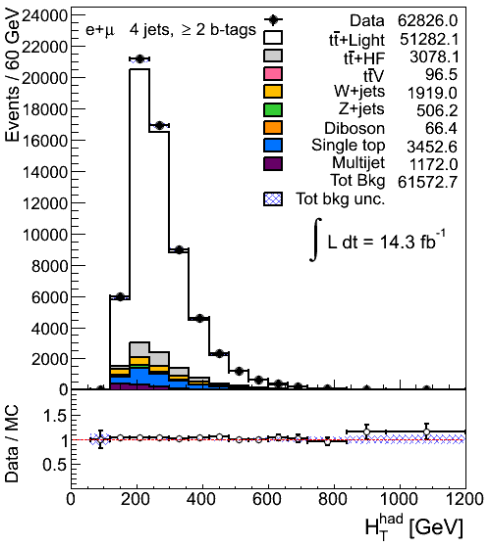
Postfit: 4jetex 0btagex



4jetex 1btagex

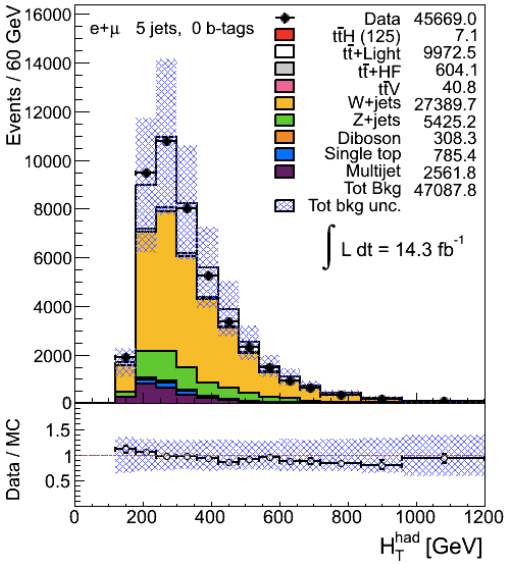


4jetex 2btagin

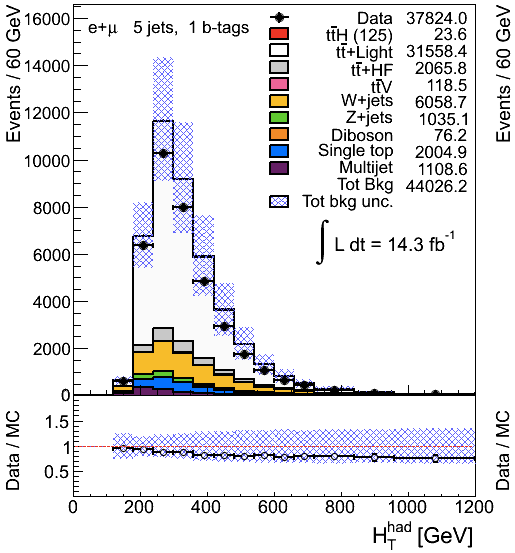


Pre- and Post-fit in validation regions: H_T

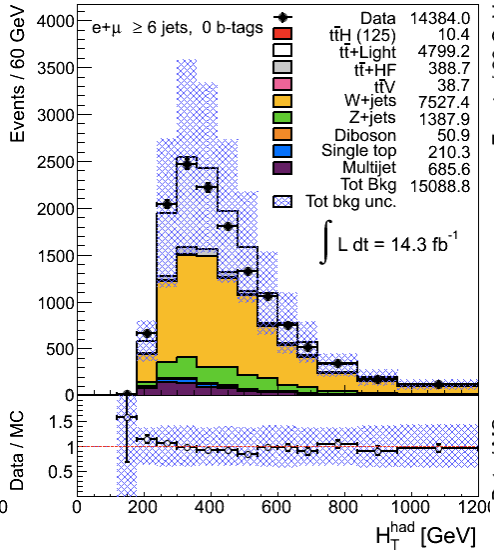
Pre-fit



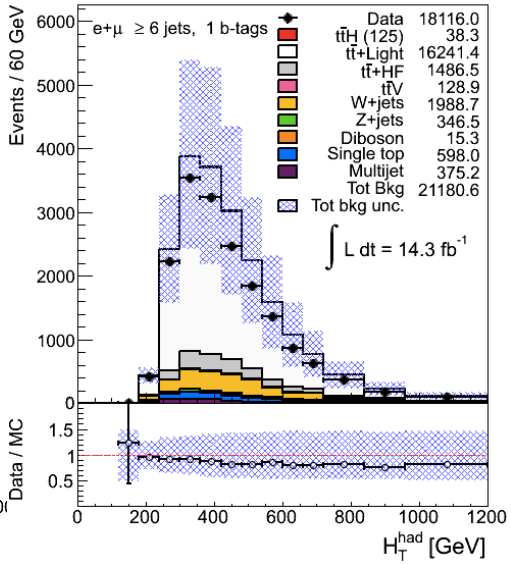
5 jets 0 btags



5 jets 1 btags

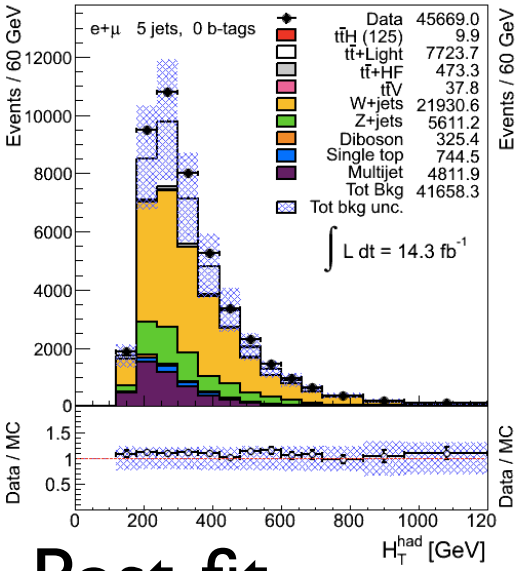


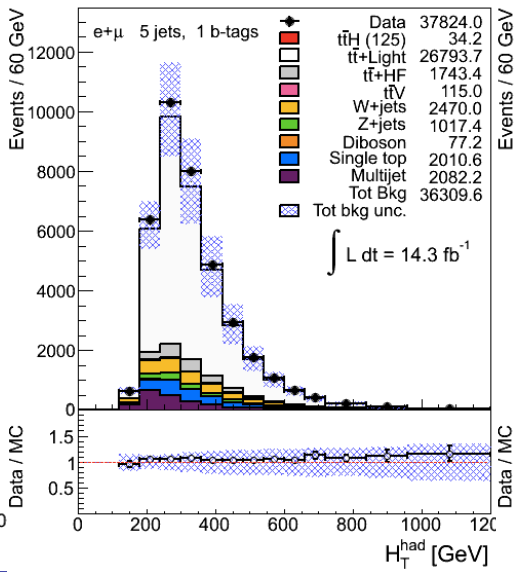
6 jets 0 btags

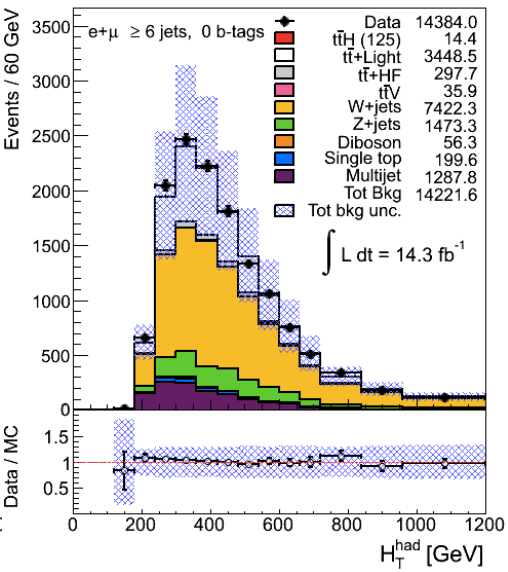


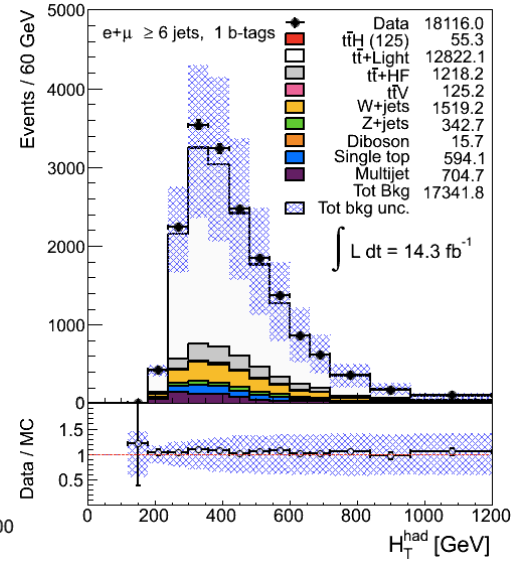
6 jets 1 btags

Post-fit





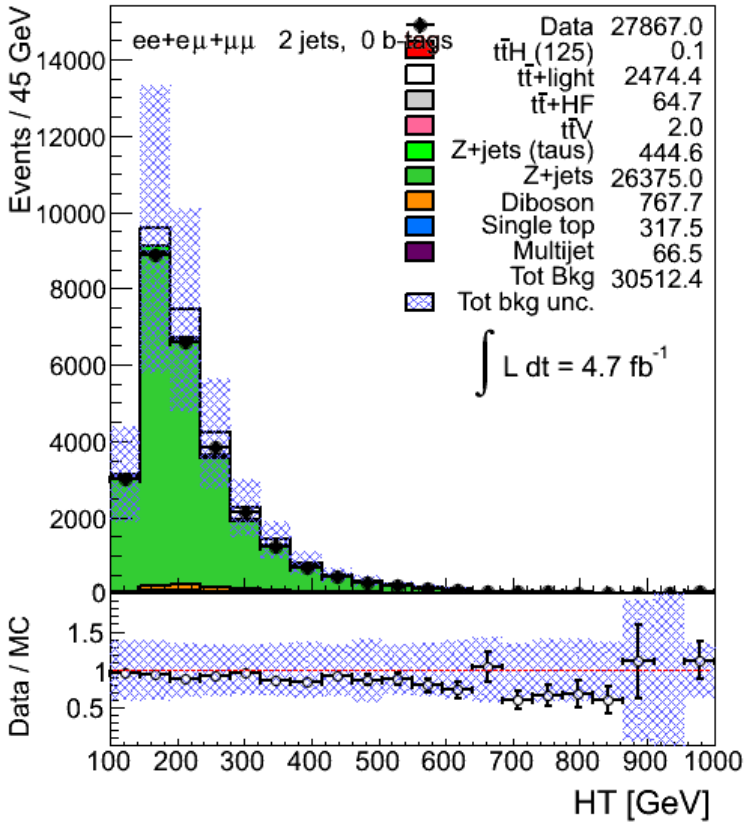




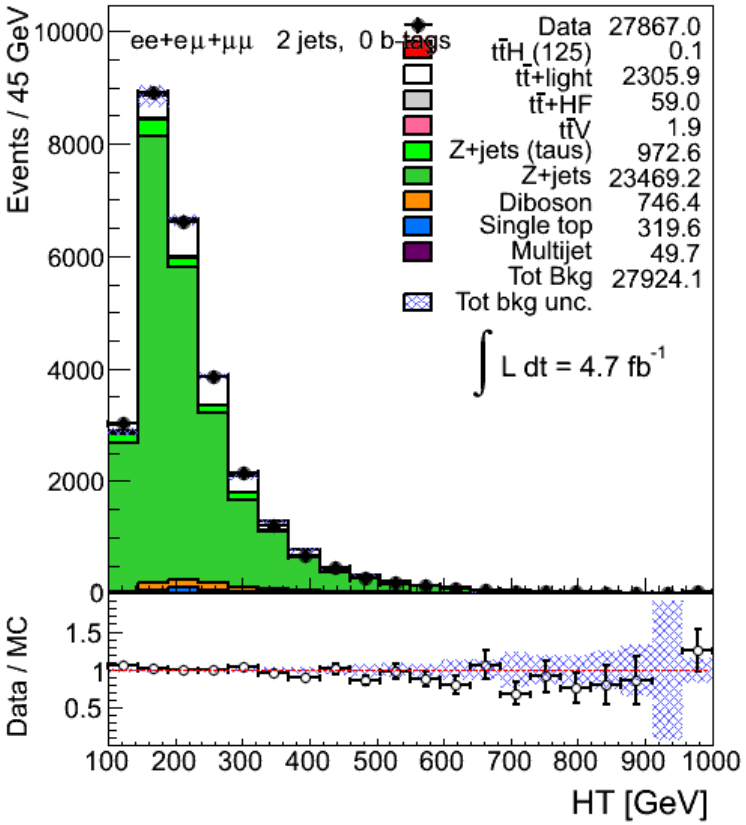
8TeV Dileptons: Pre and Post Fit Plots (Valid.reg.)

b-tags:	0	1	2	3	≥ 4
2 jets	H_T	H_T	H_T	-	-
≥ 3 jets	H_T	H_T	H_T	H_T	-

Prefit HT



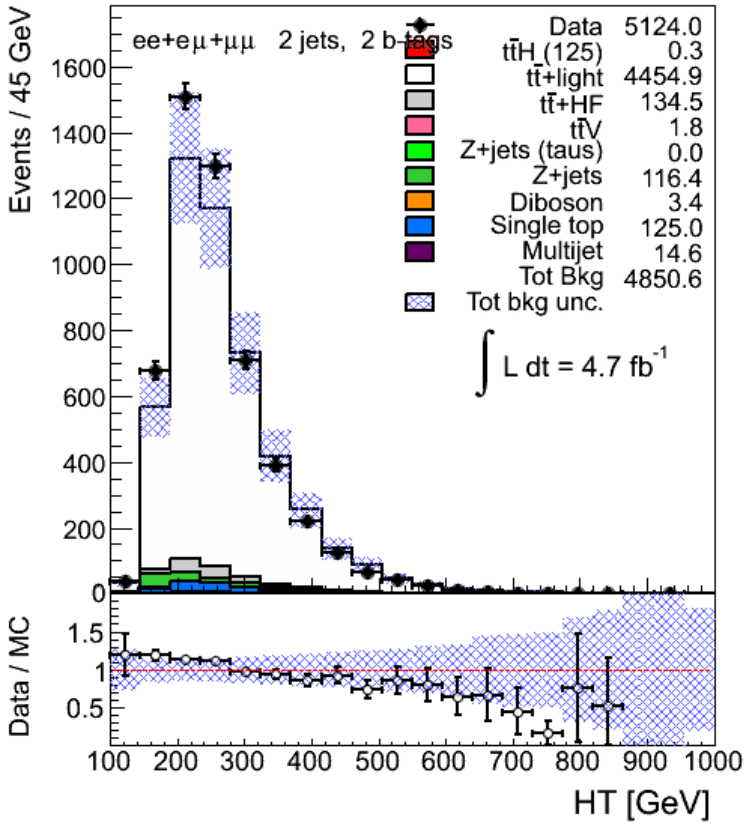
Postfit HT



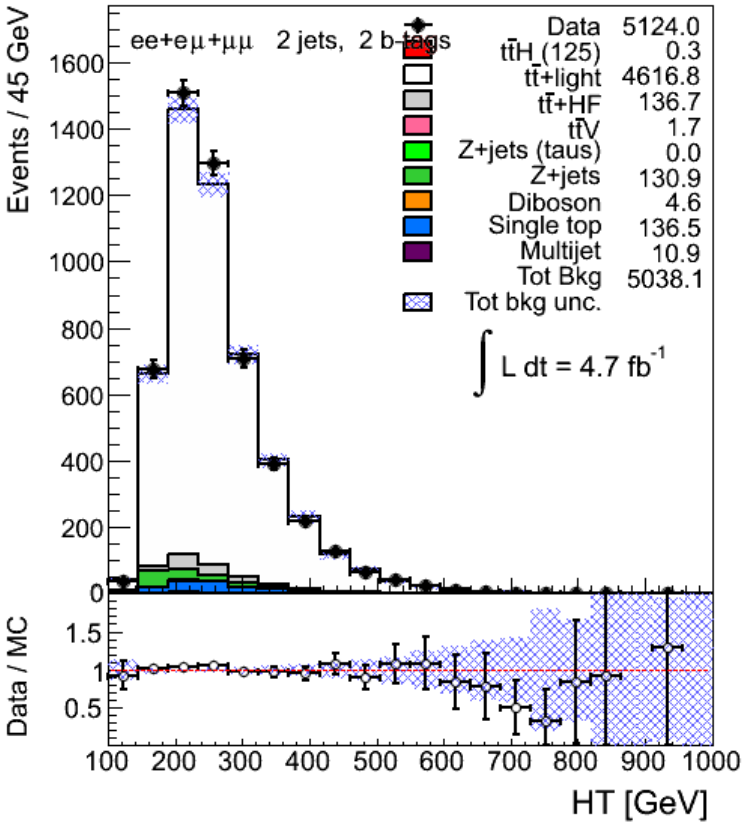
Dileptons: Pre and Post Fit Plots (Signal)

b-tags:	0	1	2	3	≥ 4
2 jets	H_T	H_T	H_T	-	-
≥ 3 jets	H_T	H_T	H_T	H_T	-

Prefit HT



Postfit HT

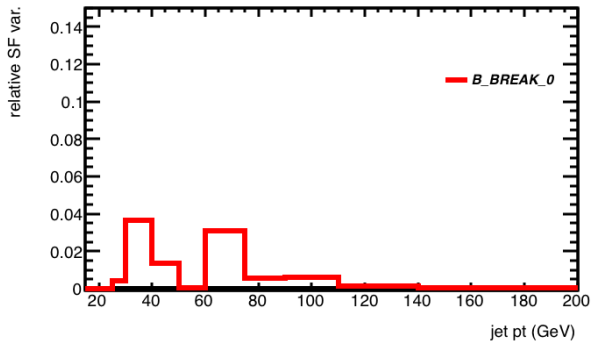


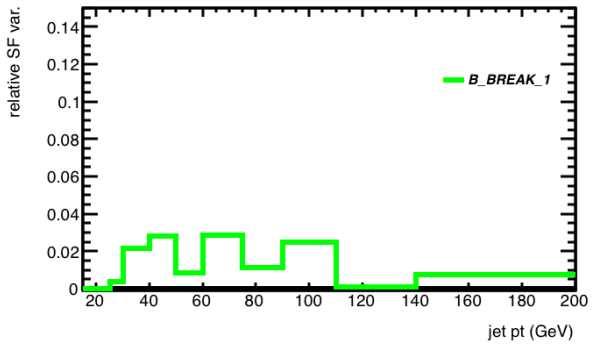
Conclusions

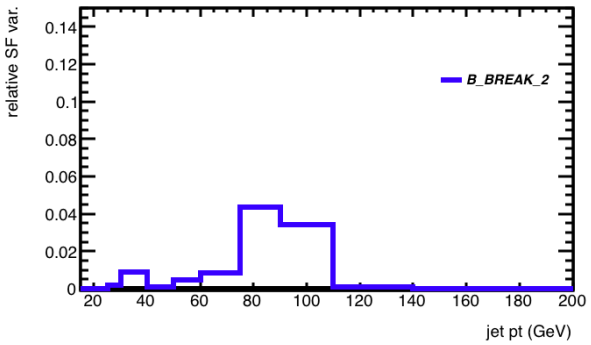
- A huge amount of work on studying HT problem
  - No silver bullet: looks like combination of several effects
- Fits looking better but a few things still to understand
- To do:
- Some improvement expected but not huge:
  - p_T^W reweighting for 8TeV
  - Compare with Z+jets p_T^Z reweighting and uncertainty derived from the dilepton analysis
  - Introduce the recent JVF SF derived for LCjets, there were only available for EM+JES jets until recently (small difference)
  - More realistic uncertainties for QCD

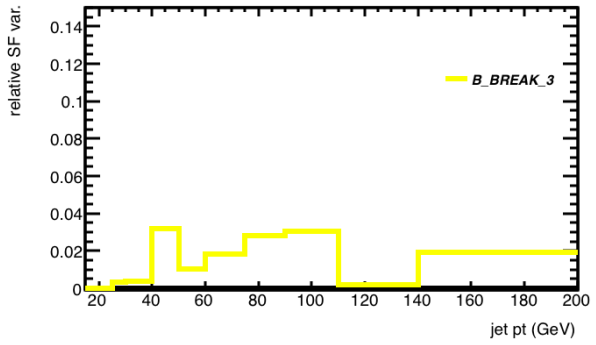
Backup

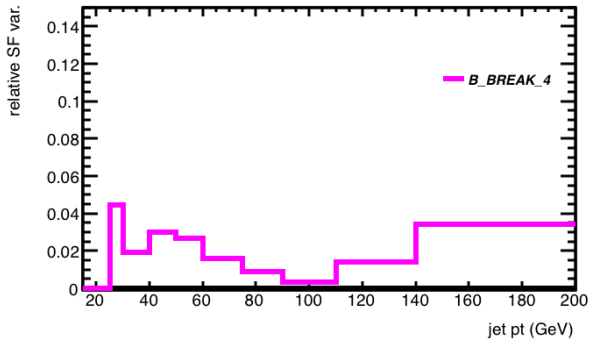
- B-tagging eigenvectors

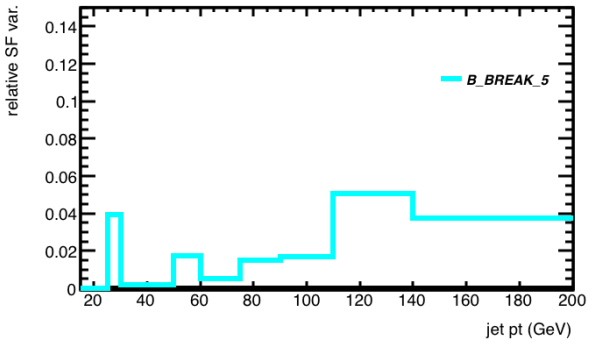


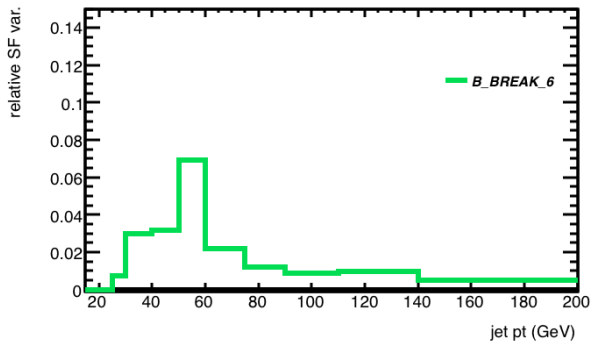


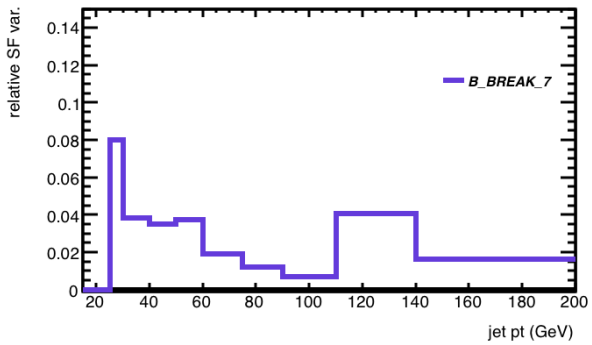


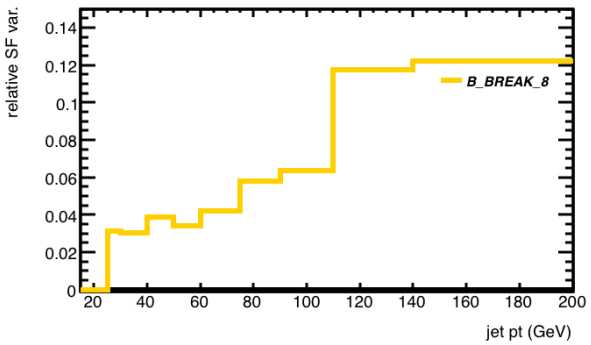






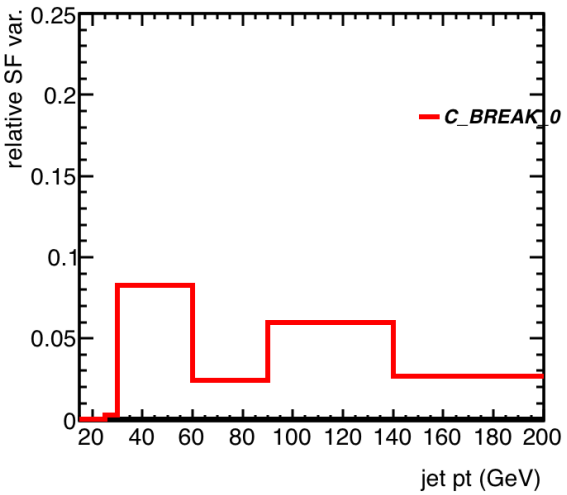


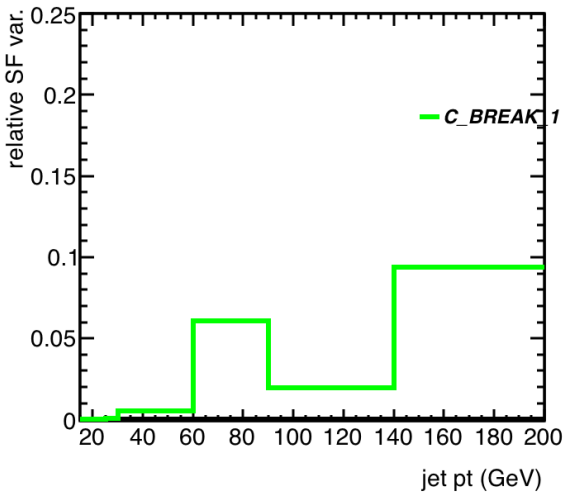


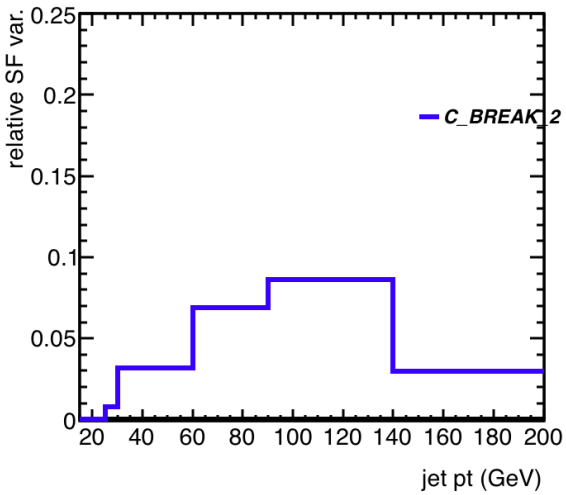


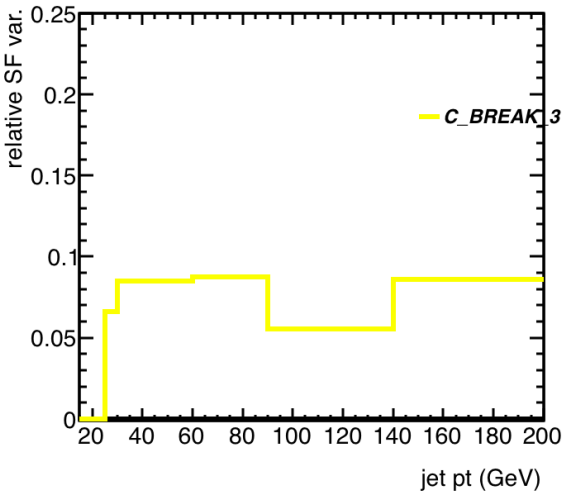
Backup

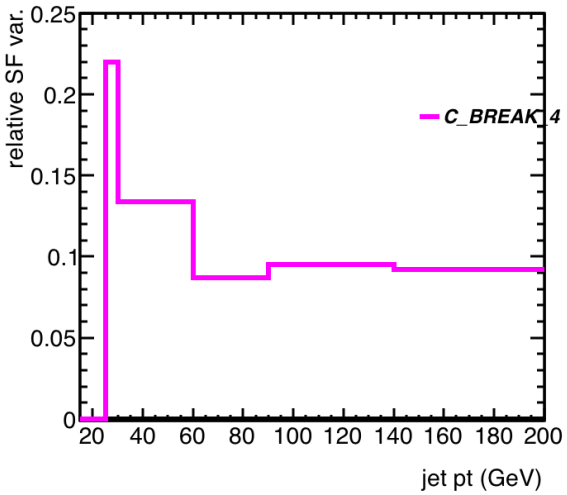
- C-tagging eigenvectors







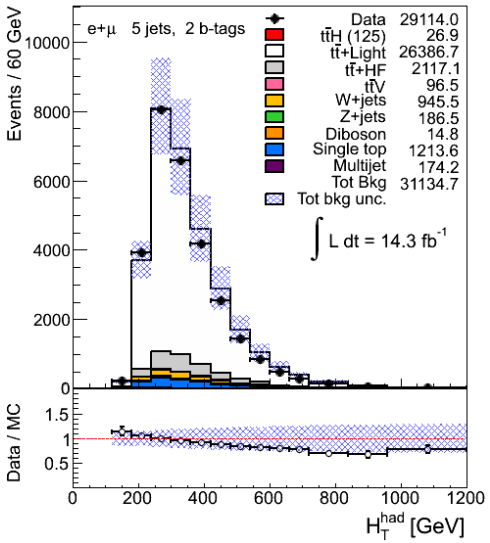




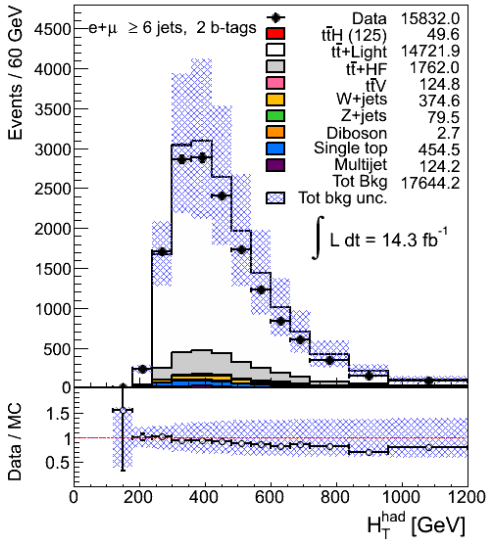
Pre/post fit plots

Prefit:

5jetex 2btagex

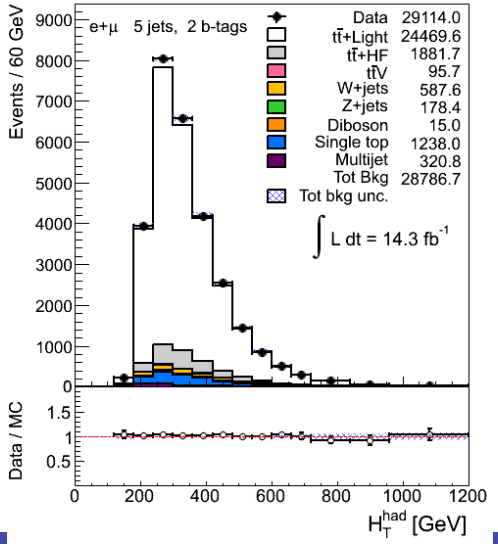


6jetex 2btagex



Postfit:

5jetex 2btagex



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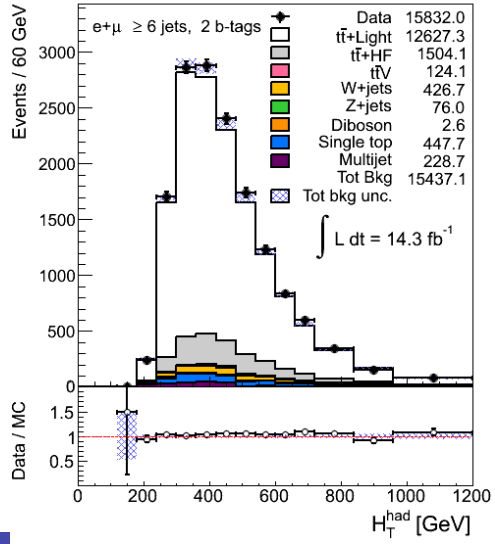
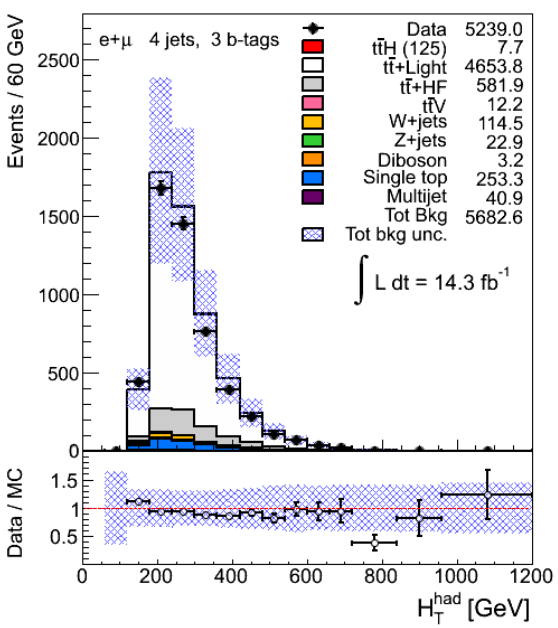
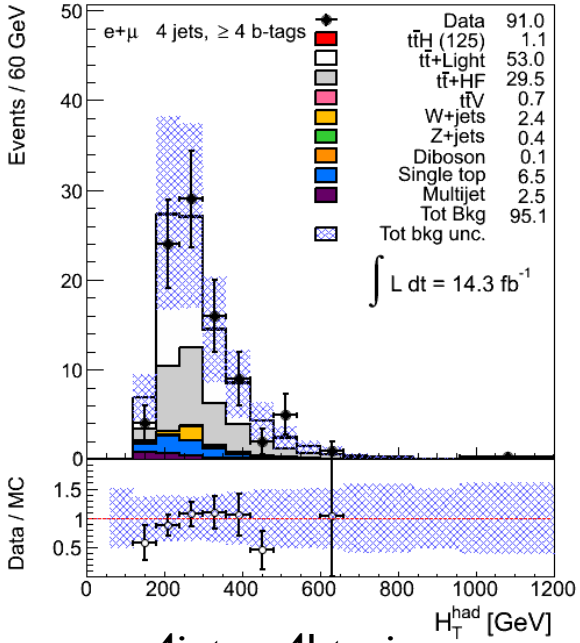


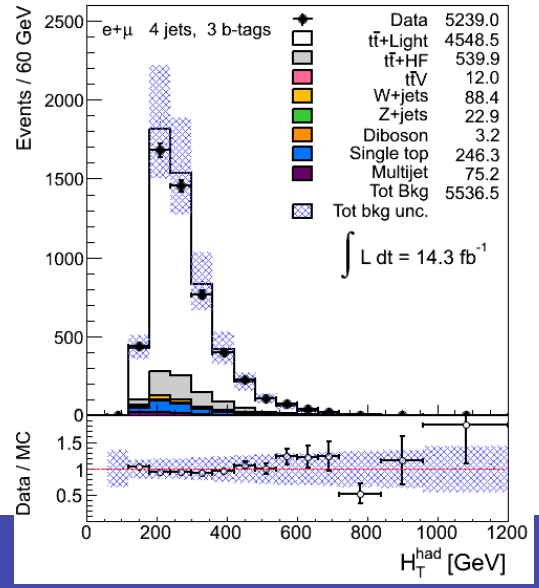
Pre/post fit plots

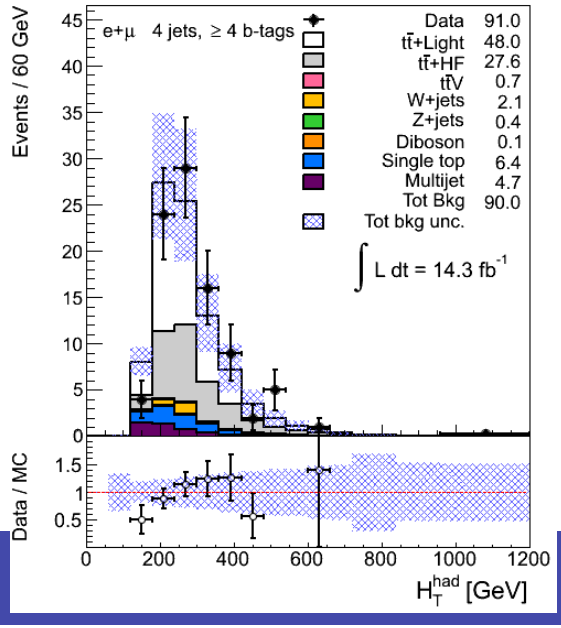
Prefit: 4jetex 3btagex 4jetex 4btagin





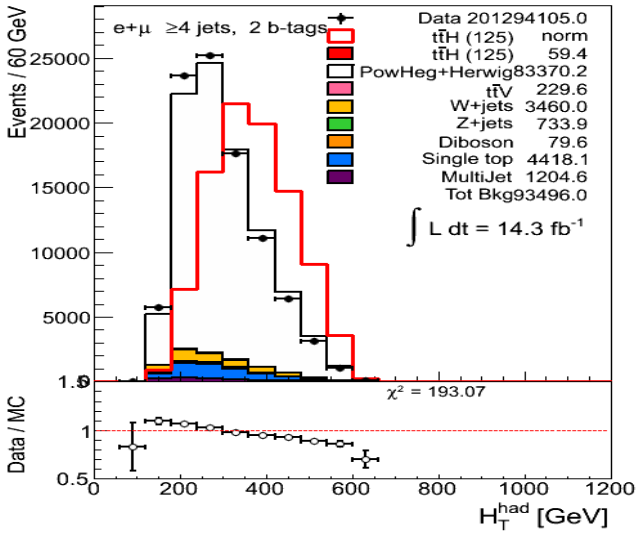
Postfit: 4jetex 3btagex 4ietex 4btagin

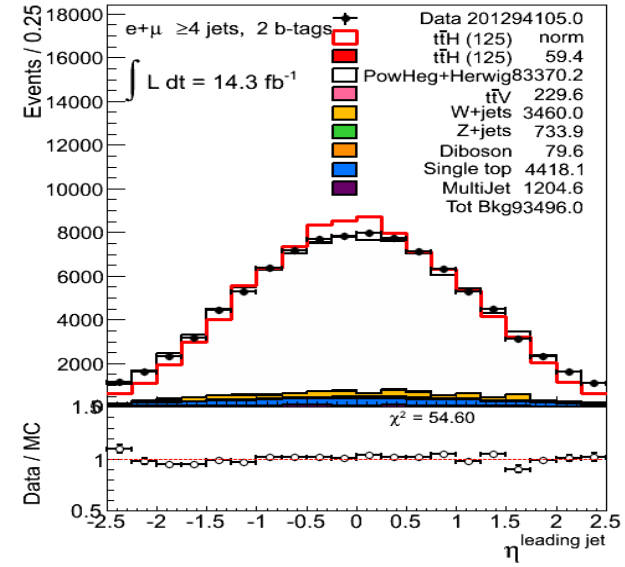




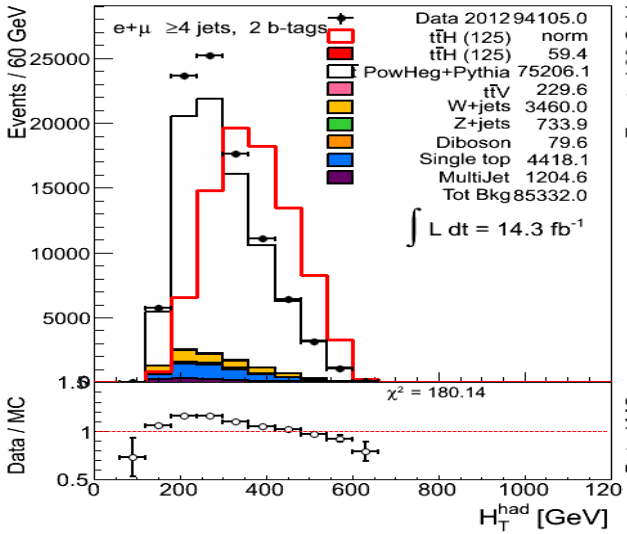
ttbar modelling - II

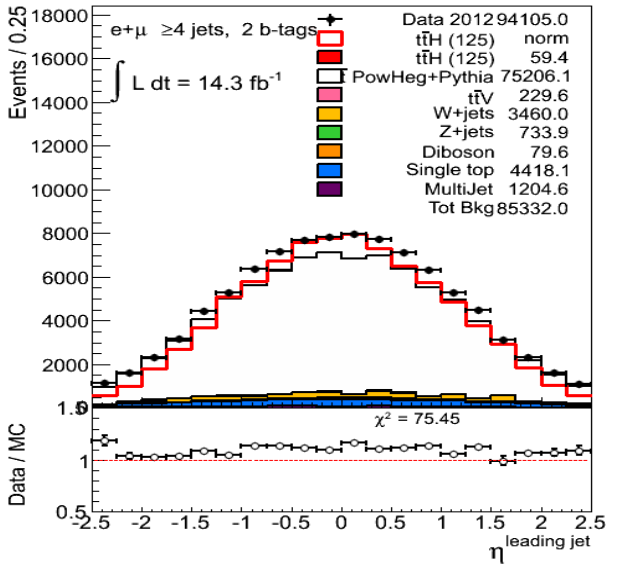
Powheg+Herwig



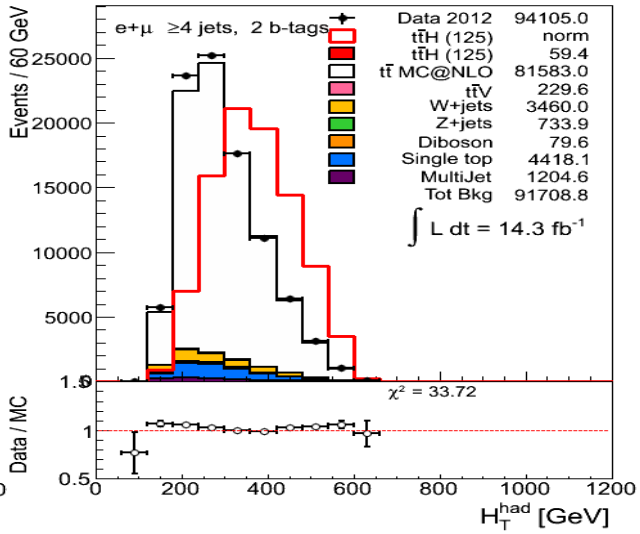


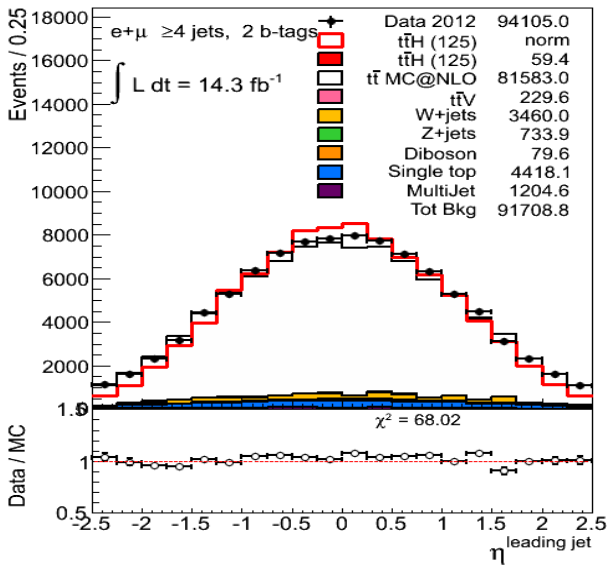
Powheg+Pythia





MC@NLO





NLO MC describes jet η distribution better

Systematics in 6jetin 0btagex

$\geq$ 6 jets, 0 b-tags

	$t\bar{t}$H (125)	$t\bar{t}$-HF	$t\bar{t}$-Light	W+jets	Z+jets	Single top	Diboson	$t\bar{t}V$	Multijet
BTAGBREAK0	+0.4/-0.4	+0.4/-0.4	+0.4/-0.4	+0.0/+0.0	+0.0/+0.0	+0.1/-0.1	+0.0/+0.0	+0.2/-0.2	–
BTAGBREAK1	+0.4/-0.4	+0.4/-0.4	+0.4/-0.4	+0.0/+0.0	+0.0/+0.0	+0.5/-0.5	+0.0/+0.0	+0.4/-0.4	–
BTAGBREAK2	+0.2/-0.2	+0.2/-0.2	+0.1/-0.1	+0.0/+0.0	+0.0/+0.0	+0.5/-0.4	+0.0/+0.0	+0.2/-0.2	–
BTAGBREAK3	+0.2/-0.2	+0.3/-0.3	+0.4/-0.4	+0.0/+0.0	+0.0/+0.0	+0.1/-0.1	+0.0/+0.0	+0.2/-0.2	–
BTAGBREAK4	+0.8/-0.9	+1.2/-1.2	+1.3/-1.3	+0.0/+0.0	+0.0/+0.0	+0.6/-0.7	+0.0/+0.0	+0.8/-0.8	–
BTAGBREAK5	+1.0/-1.1	+0.8/-0.8	+0.7/-0.7	+0.0/+0.0	+0.1/-0.1	+0.9/-0.9	+0.0/+0.0	+0.9/-0.9	–
BTAGBREAK6	+0.6/-0.6	+0.9/-0.9	+0.7/-0.7	+0.0/+0.0	+0.0/+0.0	+0.4/-0.3	+0.0/+0.0	+0.6/-0.6	–
BTAGBREAK7	+1.2/-1.2	+1.5/-1.5	+1.5/-1.6	+0.0/-0.0	+0.0/-0.0	+1.3/-1.3	+0.0/-0.0	+1.1/-1.1	–
BTAGBREAK8	+1.8/-2.1	+1.8/-2.0	+1.6/-1.8	+0.0/-0.0	+0.1/-0.1	+1.4/-1.6	+0.0/-0.0	+1.7/-1.9	–
CTAGBREAK0	+0.2/-0.2	+0.4/-0.4	+0.1/-0.1	+0.0/+0.0	+0.1/-0.1	+0.1/-0.1	+0.4/-0.4	+0.1/-0.1	–
CTAGBREAK1	+0.2/-0.2	+0.2/-0.2	+0.1/-0.1	+0.0/+0.0	+0.0/+0.0	+0.1/-0.1	+0.1/-0.1	+0.2/-0.2	–
CTAGBREAK2	+0.1/-0.1	+0.2/-0.2	+0.1/-0.1	+0.1/-0.1	+0.0/+0.0	+0.1/-0.1	+0.1/-0.1	+0.2/-0.2	–
CTAGBREAK3	+0.9/-0.9	+1.2/-1.2	+0.5/-0.5	+0.4/-0.5	+0.2/-0.2	+0.5/-0.5	+0.6/-0.6	+0.9/-0.9	–
CTAGBREAK4	+1.2/-1.3	+1.9/-1.9	+0.7/-0.7	+0.7/-0.7	+0.4/-0.4	+0.7/-0.7	+1.0/-1.0	+1.2/-1.2	–
Dibosons XS	–	–	–	–	–	–	+5.0/-5.0	–	–
JER	+0.2/-0.2	+0.5/-0.5	+0.4/-0.4	+1.1/-1.1	+2.3/-2.3	+1.0/-1.0	+2.3/-2.3	+0.3/-0.3	–
JESBREAK1	+0.3/-0.2	+0.5/-0.5	+0.6/-0.6	+0.9/-0.9	+0.8/-1.0	+0.6/-0.9	+0.9/-1.3	+0.3/-0.3	–
JESBREAK2	+0.4/-0.4	+0.9/-1.2	+1.2/-1.2	+2.1/-1.7	+1.2/-2.2	+1.4/-1.8	+2.3/-3.4	+0.6/-0.7	–
JESBREAK3	+0.2/-0.2	+0.4/-0.5	+0.5/-0.5	+1.1/-1.0	+1.0/-1.7	-0.8/-0.5	+0.1/-1.6	+0.3/-0.2	–
JESBREAK4	+0.0/+0.0	+0.2/-0.2	+0.3/-0.3	+0.8/-0.6	+0.9/-0.6	+0.2/-0.1	+0.5/-1.9	+0.2/-0.1	–
JESBREAK5	+0.3/-0.4	+0.6/-0.7	+0.9/-0.9	+1.9/-1.6	+1.1/-1.8	+1.1/-1.5	+1.7/-3.8	+0.4/-0.4	–
JESBREAK6	+0.6/-0.6	+1.0/-1.1	+1.2/-1.2	+1.9/-2.1	+1.7/-2.2	+1.4/-2.1	+1.6/-2.5	+0.8/-0.7	–
JESBREAK7	+0.3/-0.3	+0.6/-0.6	+0.7/-0.6	+1.1/-1.0	+0.9/-1.1	+0.7/-0.9	+0.9/-1.2	+0.4/-0.4	–
JESBREAK8	+0.3/-0.4	+0.2/-0.3	+0.2/-0.1	+0.0/+0.0	+0.0/-0.2	+0.0/-0.2	+0.0/+0.0	+0.3/-0.2	–
JVFSF	+1.0/-1.5	+0.9/-1.4	+0.9/-1.4	+1.0/-1.6	+1.2/-1.9	+1.0/-1.8	+1.0/-1.8	+1.0/-1.4	–
LEPTONSYS	+1.0/-1.0	+1.0/-1.0	+1.0/-1.0	+1.0/-1.0	+1.2/-1.2	+1.0/-1.0	+1.0/-1.0	+1.0/-1.0	–
LTAG	+0.7/-0.7	+0.7/-0.7	+0.7/-0.7	+1.1/-1.1	+1.1/-1.1	+0.7/-0.7	+0.9/-0.9	+0.7/-0.7	–
Luminosity	+1.3/-1.3	+1.3/-1.3	+1.3/-1.3	+1.3/-1.3	+1.3/-1.3	+1.3/-1.3	+1.3/-1.3	+1.3/-1.3	–
QCD norm	–	–	–	–	–	–	–	–	+14.6/-14.6
WJETS-BBCC	–	–	–	-5.5/-5.5	–	–	–	–	–
WJETS-BBCC6	–	–	–	+1.1/-1.1	–	–	–	–	–
WJETS-BBCCC	–	–	–	-9.5/-9.5	–	–	–	–	–
WJETS-C6	–	–	–	+4.3/-4.7	–	–	–	–	–
WJETS-CAN	–	–	–	-4.5/-4.5	–	–	–	–	–
Wjets XS jet6	–	–	–	+22.4/-22.4	–	–	–	–	–
Zjets XS jet56	–	–	–	–	+22.8/-22.8	–	–	–	–
Zjets XS jet6	–	–	–	–	+23.7/-23.7	–	–	–	–
ttbar iqopt2	–	+11.6/-11.6	+16.3/-16.3	–	–	–	–	–	–
ttbar ktfac	–	+10.7/-13.2	+13.5/-16.7	–	–	–	–	–	–
ttbar qfac	–	+1.0/-1.0	+1.6/-1.6	–	–	–	–	–	–
singleTop XS	–	–	–	–	–	+3.1/-2.4	–	–	–
ttbarHF	–	+12.8/-12.8	+3.3/-3.3	–	–	–	–	–	–
ttbarV XS	–	–	–	–	–	–	–	+29.7/-29.7	–
ttbar XS	–	+1.1/-1.2	+1.1/-1.2	–	–	–	–	–	–
Total	+3.3/-3.4	+29.5/-31.7	+31.2/-34.4	+25.7/-25.3	+33.0/-33.1	+5.3/-4.7	+6.4/-7.2	+29.9/-29.9	+14.6/-14.6