H→bb search and b-tagging

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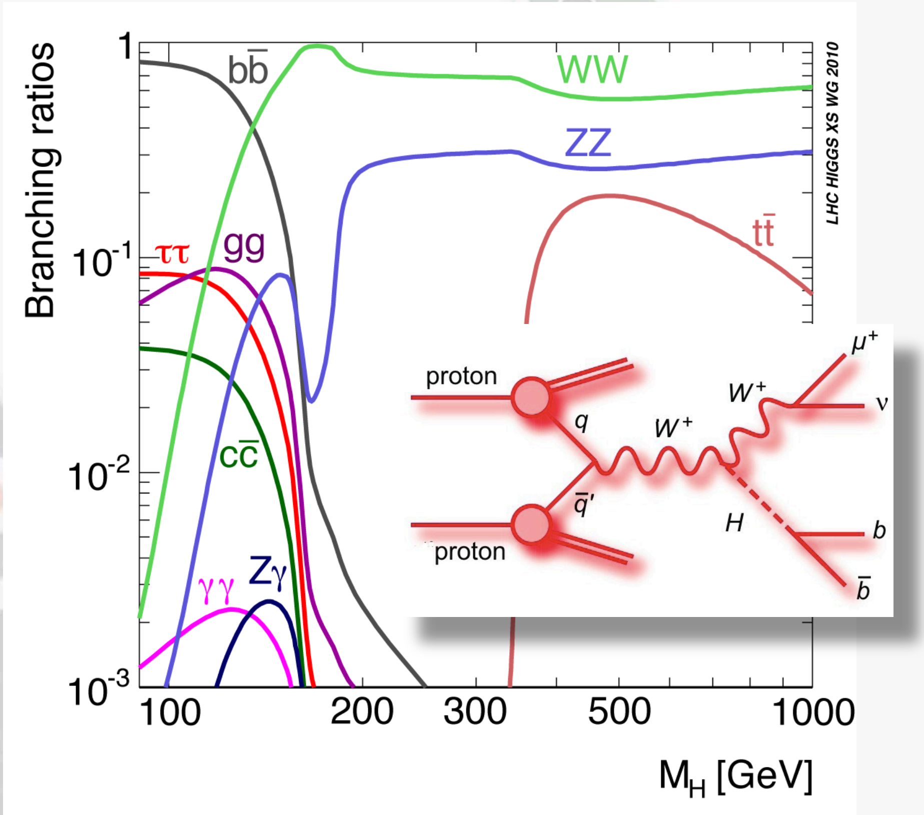
on behalf of the Higgs subgroup 5

- So far:
- H->bb dominant at low mass
- WH→lvbb, ZH→llbb
  - 1 fb^{-1} results shown in EPS2011
  - 4.7 fb^{-1} analyzed (preliminary)
  - WH σ≈2x higher than ZH
- ZH→vvbb and boosted VH
  - Coming soon - good things expected!
- ttH – first data results since Christmas
- Also: VBF, bbH – developing
- Simple & robust analyses so far
  - Get background normalization from data as much as possible
  - Search Higgs in m_{bb} spectrum
  - Critically depend on b-tagging!

CERN-2011-002; arXiv:1101.0593



m_H (GeV)	$\sigma(WH)$ (pb)	$\sigma(ZH)$ (pb)	Branching Ratios $H \to b\bar{b}$
110	0.8754	0.4721	0.745
115	0.7546	0.3598	0.705
120	0.6561	0.3158	0.649
125	0.5729	0.2778	0.578
130	0.5008	0.2453	0.494

Systematic Uncertainties

- Dominant systematic errors from b-tagging efficiency in both analyses
- Followed by jet energy scale
- Points at the next things things to improve!

(*) shown numbers for $1fb^{-1}$

ZH→llbb

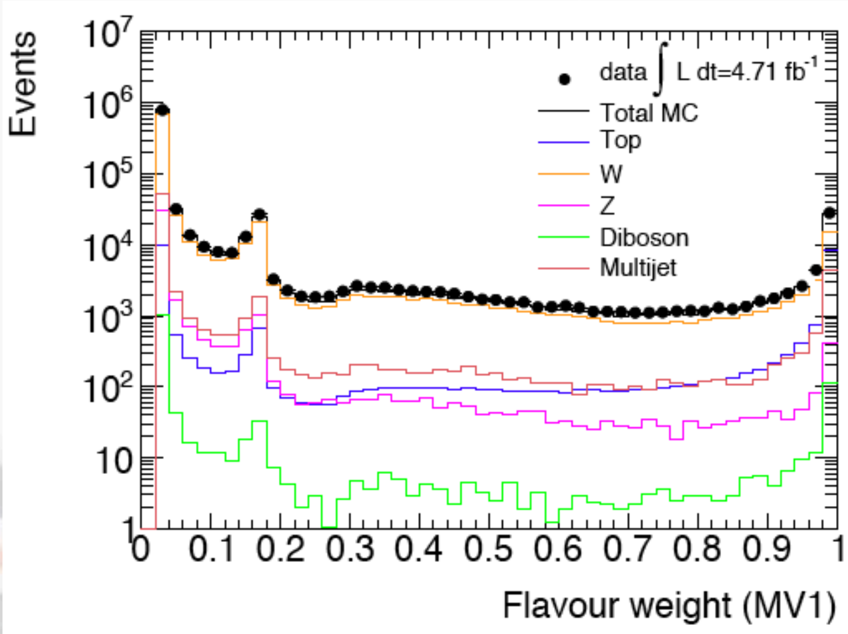
Source of Uncertainty	Effect on the signal $m_H = 115$ GeV	$m_H = 130$ GeV
Electron Energy Scale	< 1%	< 1%
Electron Energy Resolution	< 1%	< 1%
Muon Momentum Resolution	1%	3%
Jet Energy	9%	7%
Jet Energy Resolution	< 1%	< 1%
Missing Transverse Energy	2%	2%
b-tagging Efficiency	16%	17%
b-tagging Mis-tag Rate	< 1%	< 1%
Electron Efficiency	1%	1%
Muon Efficiency	1%	1%
Luminosity	4%	4%
Higgs Cross-section	5%	5%

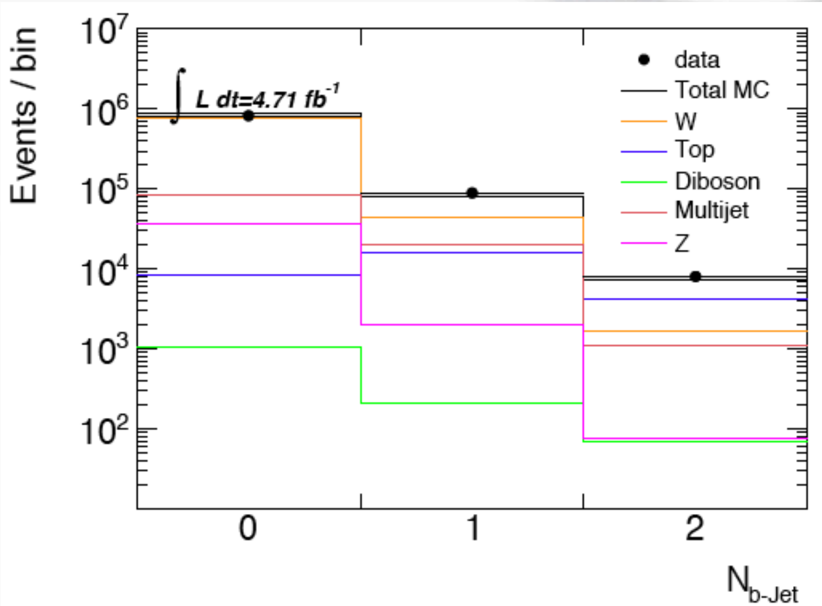
WH→lνbb

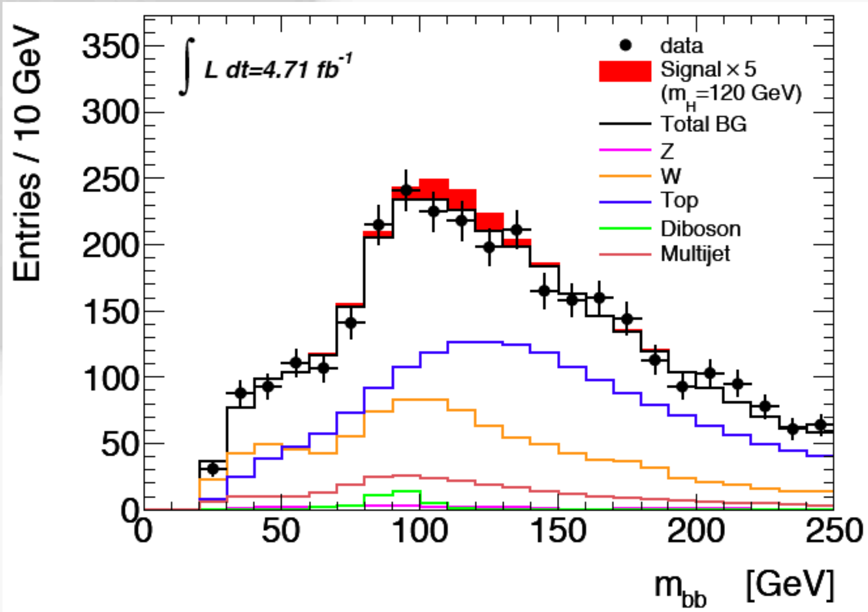
Source of Uncertainty	Effect on the signal $m_H = 115$ GeV	$m_H = 130$ GeV
Electron Energy Scale	1%	1%
Electron Energy Resolution	1%	1%
Muon Momentum Resolution	4%	1%
Jet Energy	1%	3%
Jet Energy Resolution	1%	1%
Missing Transverse Energy	2%	3%
b-tagging Efficiency	16%	17%
b-tagging Mis-tag Fraction	3%	3%
Electron Efficiency	1%	1%
Muon Efficiency	1%	1%
Luminosity	4%	4%
Higgs Cross-section	5%	5%

Current status

- Expect exclusion of around 3.5-4 x SM for m(H)=120GeV
- ZH/WH analyses just moved to MV1 and all looks ok so far
- But lots still to do before Moriond…

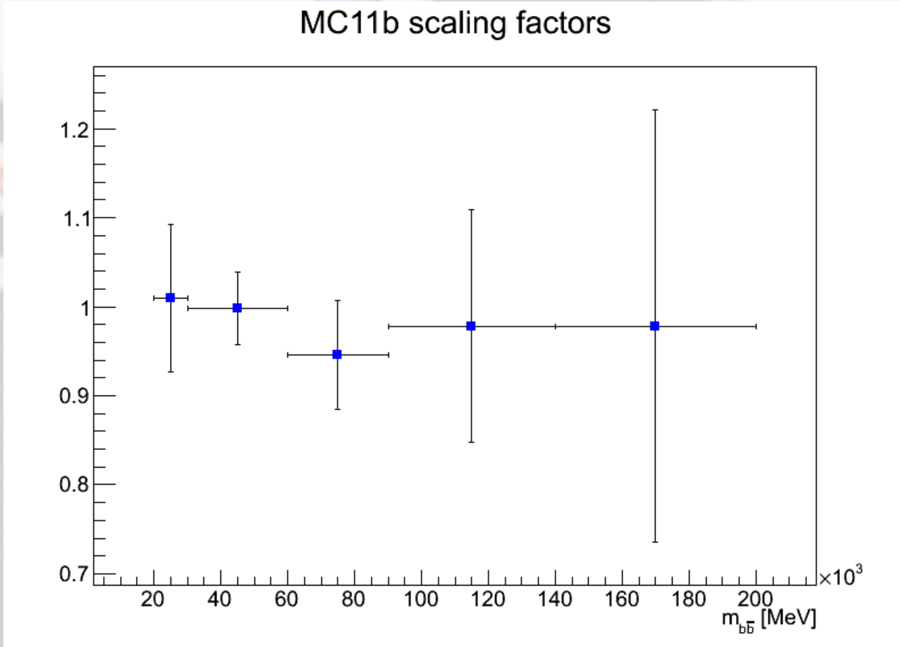






Effect of *b*-tagging Scale Factors on M_{bb} distribution

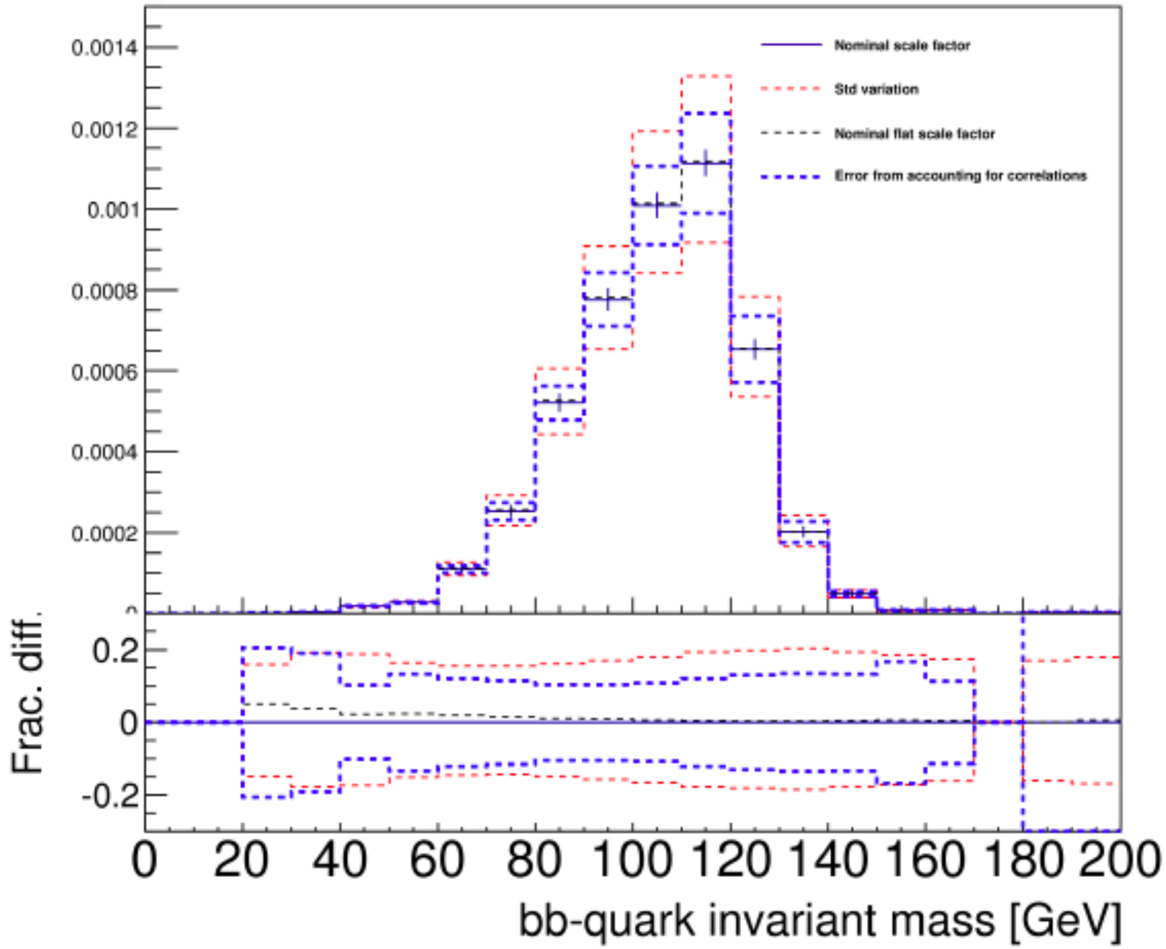
- B-tagging scale factors enter the analysis as a weight for each b-jet, and depends on jet p_T
- This introduces a distortion in the jet p_T distribution
- …which potentially introduces a distortion on the shape of the invariant mass
- May be important since we are looking for a small excess in the form of a wide peak in m(bb)
- We propose to average scaling factors propagate SF uncertainties into systematic uncertainties
- The MC11b scaling factors at present show little evidence of a p_T dependence
- But such a dependence would clearly be possible



Effect on WH signal

Giacinto P

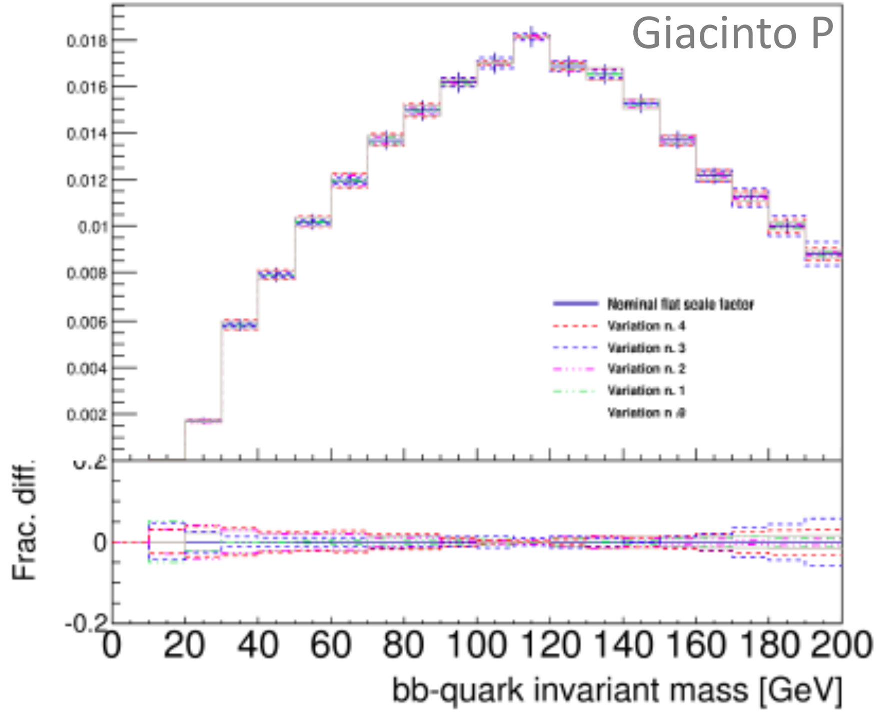
- Estimate b-tagging uncertainty on true b- and c-jets:
  - vary scale factors 5 times up and down according to eigenvectors of measured covariance matrix from pTrel
- Compare:
  - Red: „std“ method
  - Blue: new method
- The overall signal uncertainty changes from **~18%** to **~11%**.
- B-tagging scale factor uncertainty among bins is largely uncorrelated (e.g. due to MC statistics)

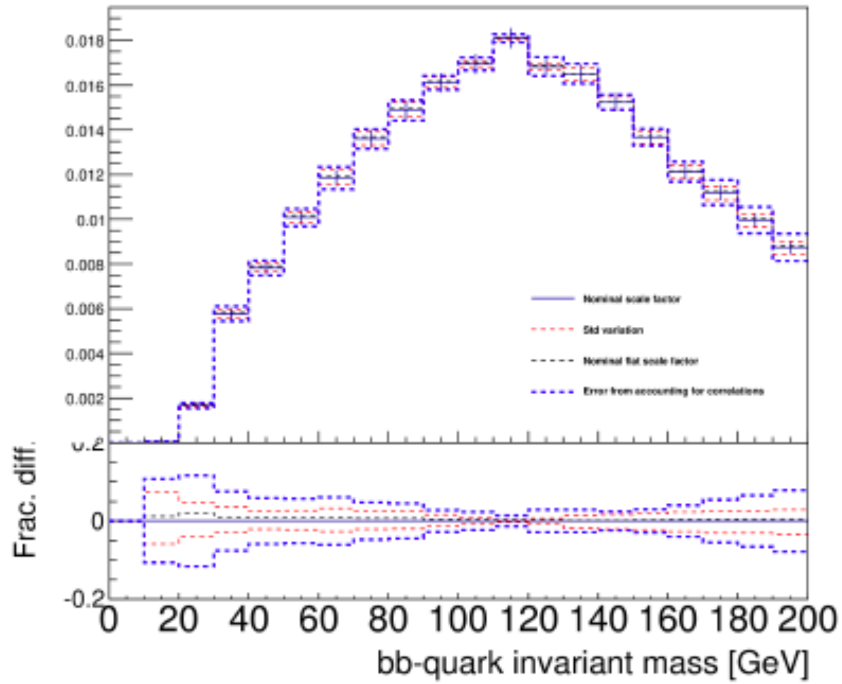


Effect on ttbar background

Giacinto P

- Here what matters for us is the effect induced on the shape, not the normalization
- To estimate the effect, normalize again after each variation.
- Combine by summing up in quadrature and compare **new** with **old** method
- Systematic uncertainty on shape increased by factor ~2
- Similar behaviour expected for the Wbb background

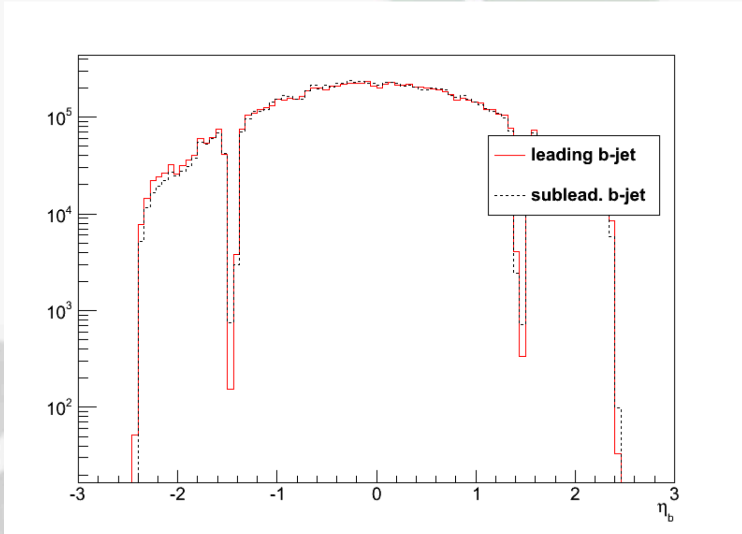


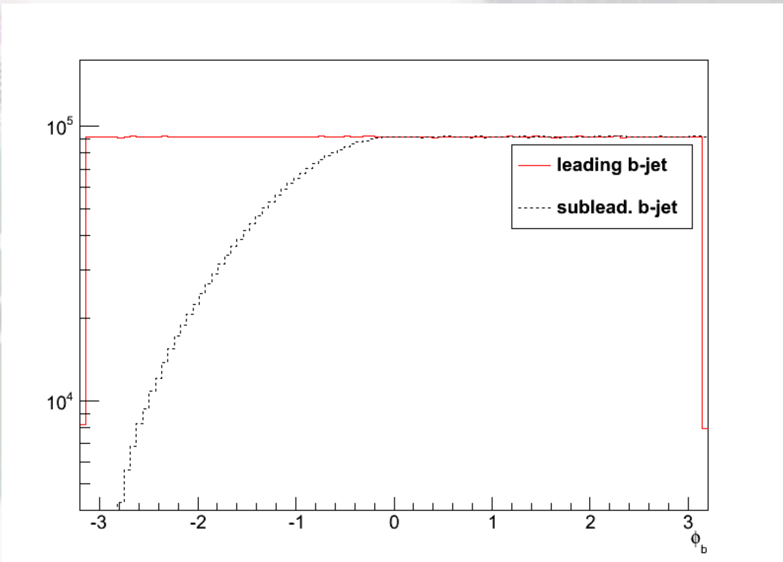


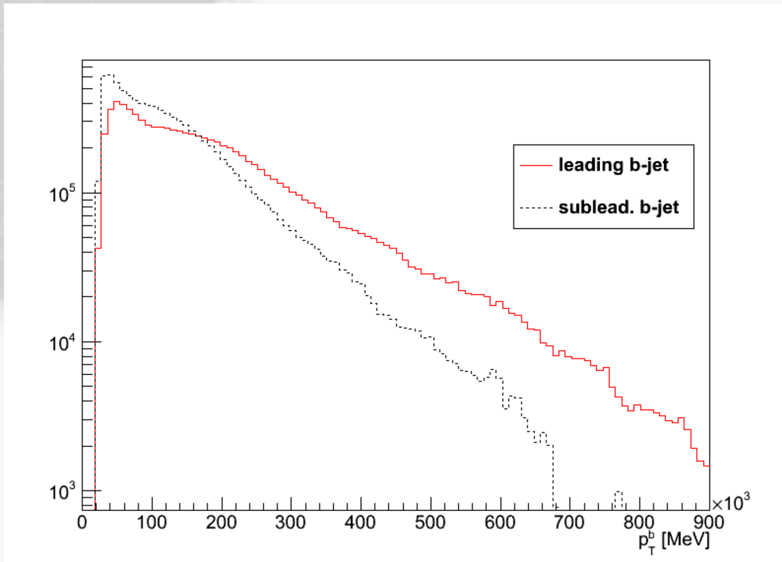
Toy Monte Carlo study of mass distortion

- Toy MC to study the effect of b-tag scale factors
- Caveat: first study done with di-photon MC kinematics – a look at bb background later

1. Sample p_T and η of leading and subleading b-jets
2. Generate flat $\phi_{\text{lead b-jet}}$ and flat mass distribution
3. Calculate $\phi_{\text{sublead b-jet}}$ to be consistent with generated mass (and reject unphysical solutions)

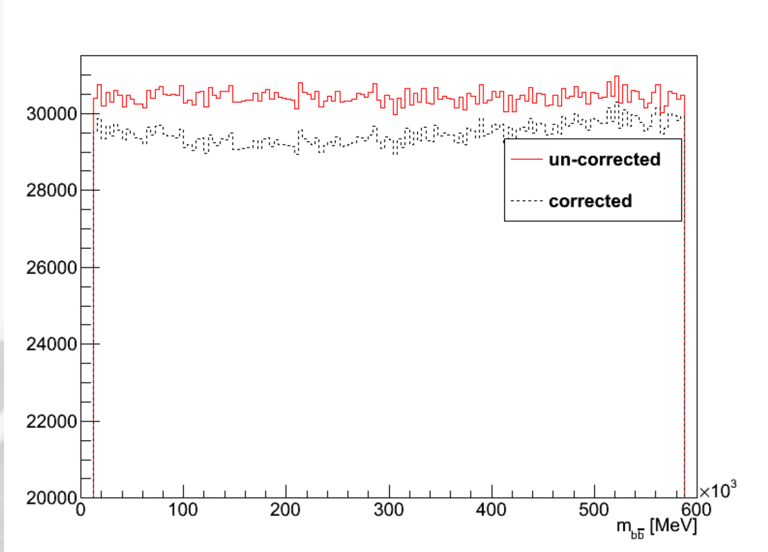


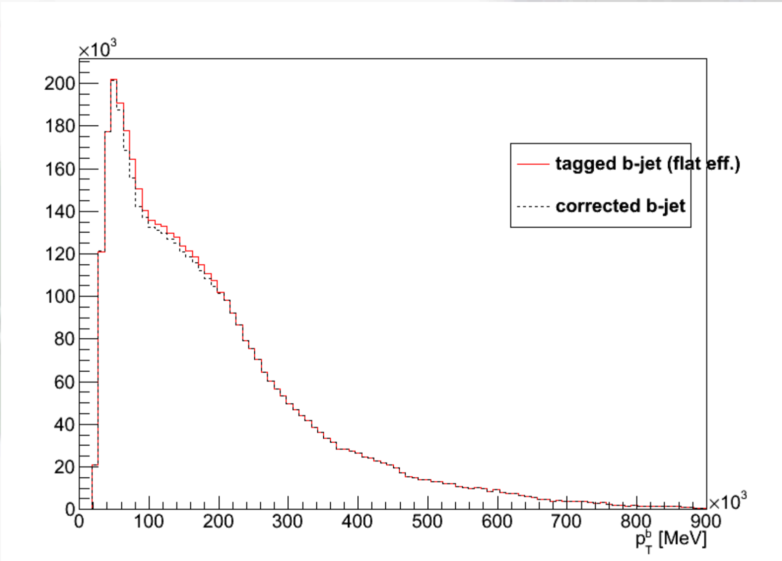


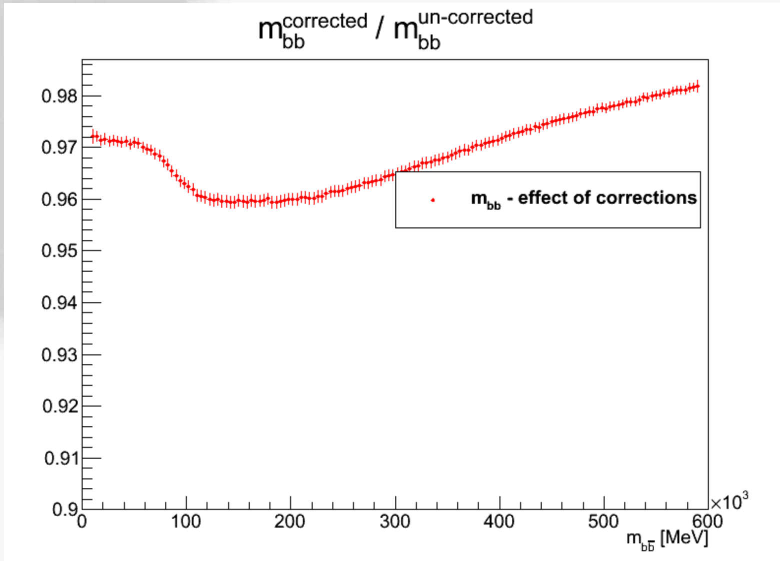


Effect of MC11b scaling factors

- The reweighting causes a distortion in the flat invariant mass distribution (plus constant term)
- The distortion is small, but then so is our signal compared to the background
- May be more serious if width comparable to m_{bb} resolution, as in our case ($\sigma_{m(bb)} \approx 20$GeV)

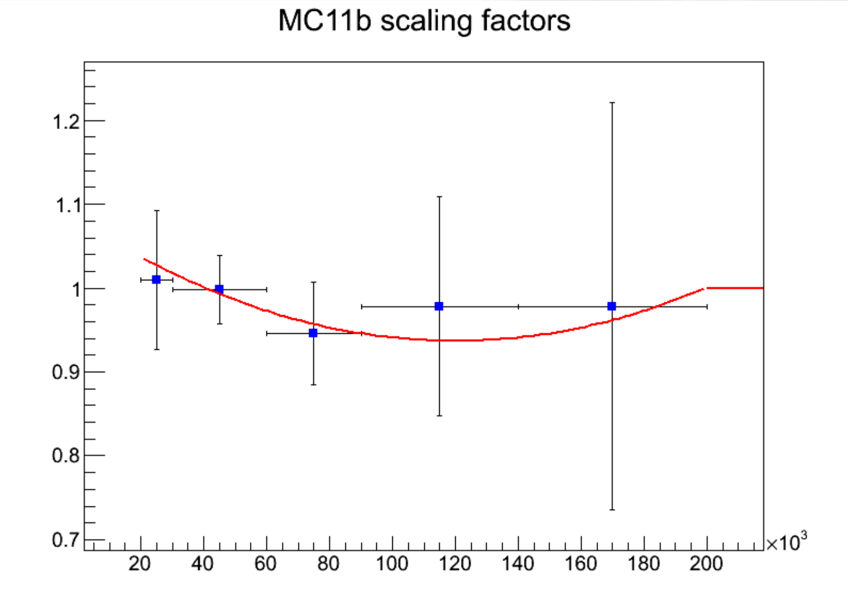


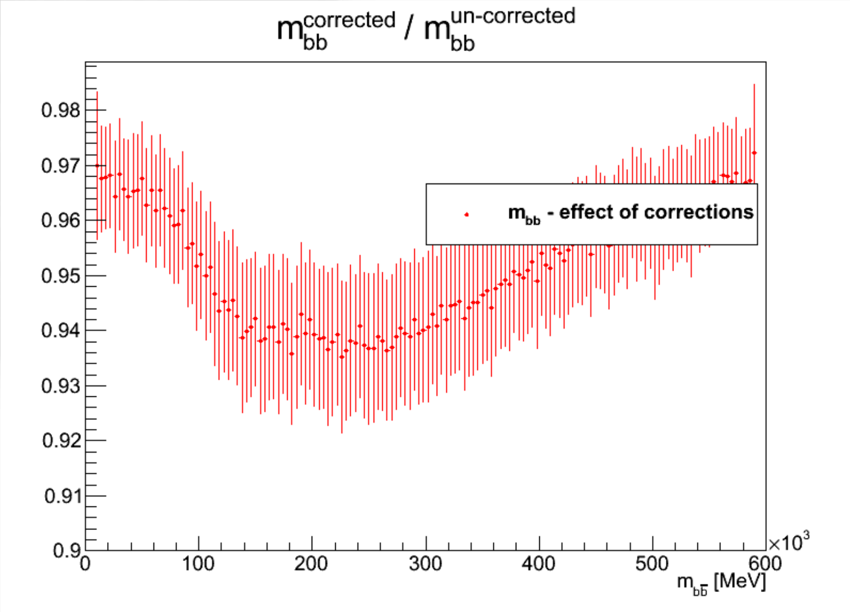




Binning effect?

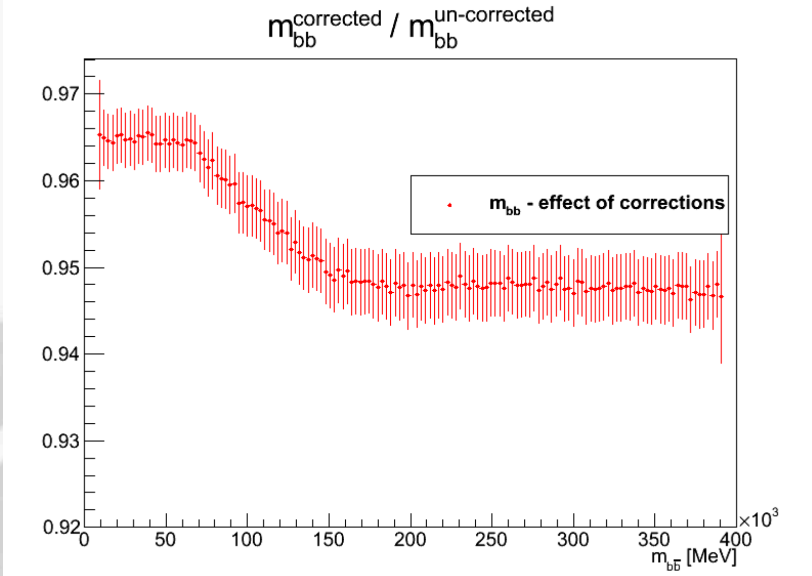
- To see whether this is an effect of the binning, fitted scaling factors (SF) with a parabola (and $\mathbf{W_b}$=1 for p_T^b>200GeV)
- Still get similar distortion => not (only) binning effect

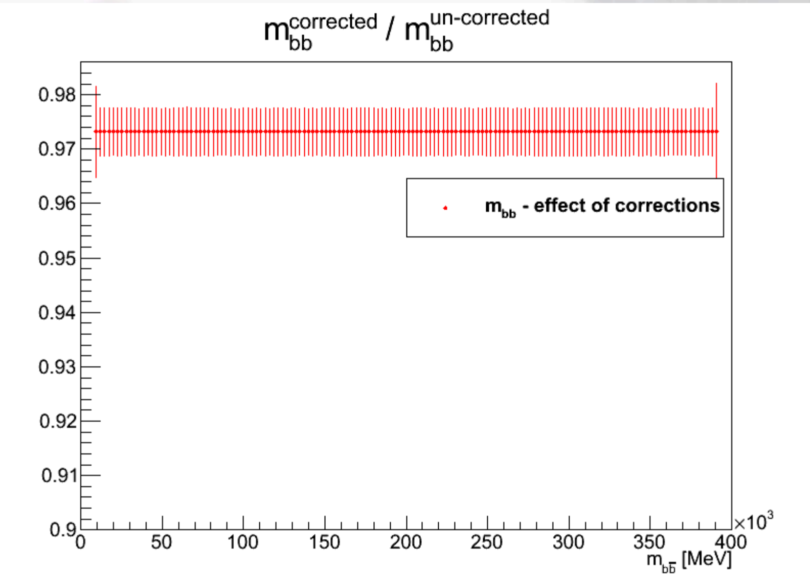


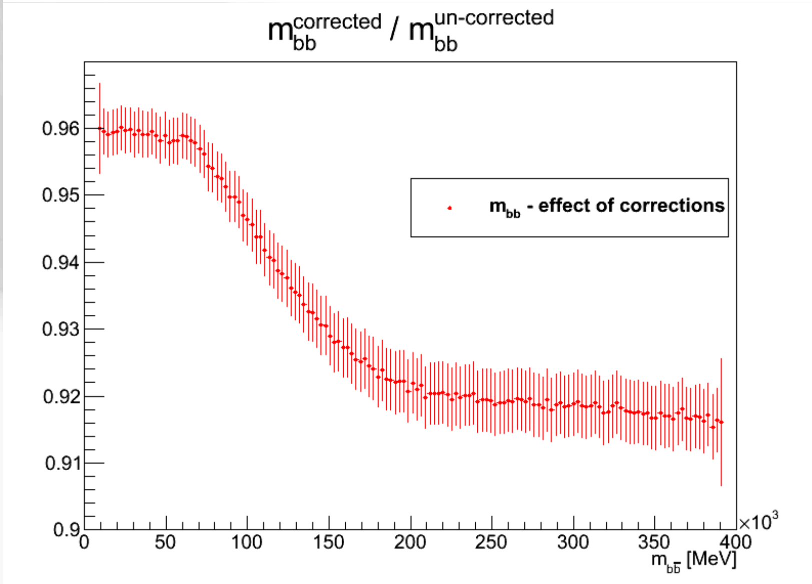


Results using background kinematics

- Basically same conclusion:
- MC11b scaling factors distort mass distribution (top right)
- Even if a parametrization is used (bottom right)
- Our averaging procedure removes shape distortion (bottom left) – note zero distortion in this case only due to jet pT cutoff at 200 GeV!

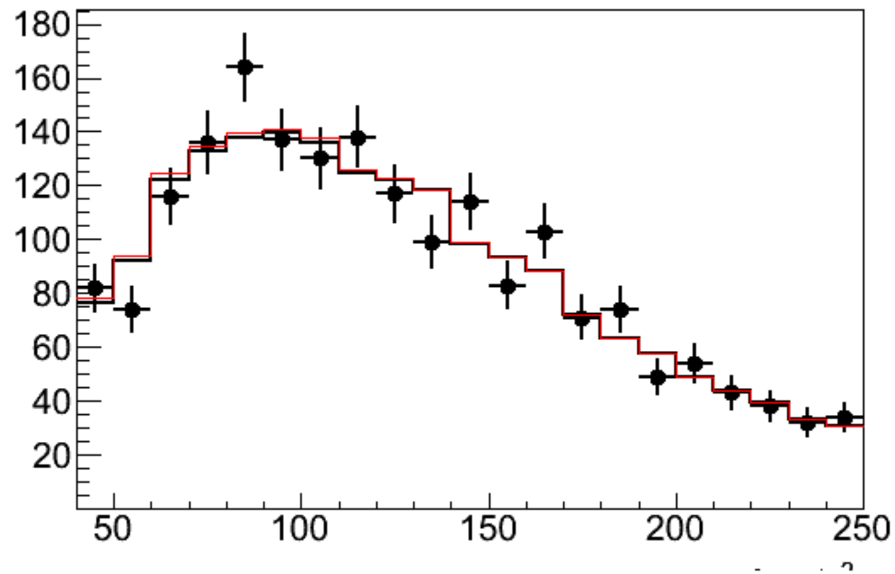


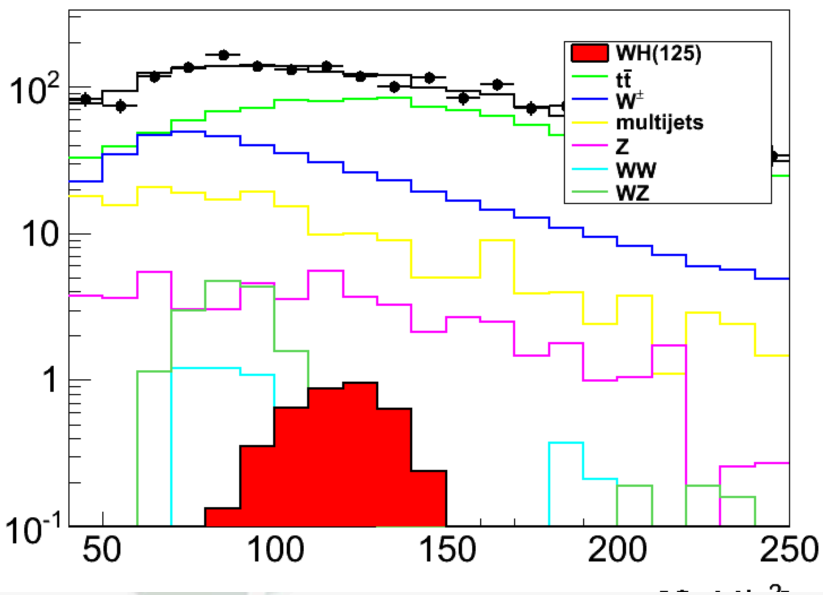


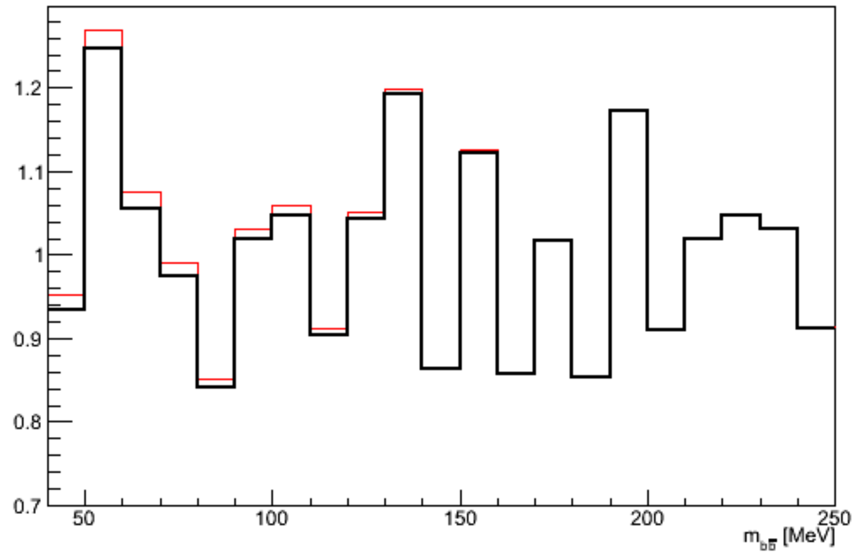


Effect on final distribution

- Well… the effect is small, but is there
- Tried applying distortion on $1fb^{-1}$ mass distribution

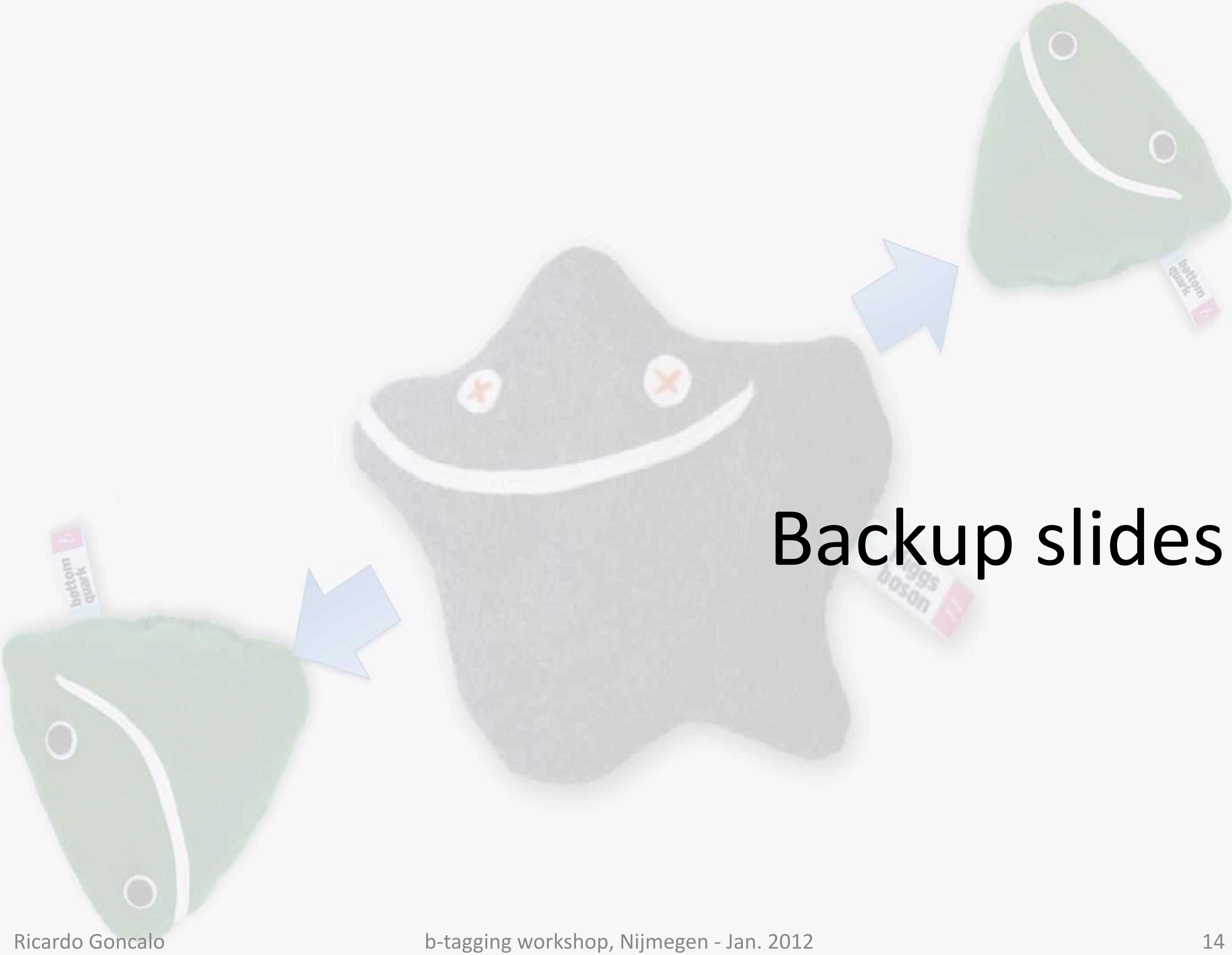






Conclusions

- These are interesting times for Higgs and H->bb!
- We depend critically on the b-tagging performance (BIG THANKS everyone!!!)
- Looked at distorting effects from p_T dependence of the b-tagging scale factors
- A method for removing the mass distortion in JFC scale factors exists and works
- May need to think again depending on what you find for MV1



Backup slides

Lepton Selection

- Electrons
  - `medium++` (`tight++`) with $p_T > 20(25)$ GeV and $|\eta| < 2.47$ for $Z(W)$
  - Include crack region
  - Track isolation: $\sum_{tracks} / p_T < 0.1$ within $\Delta R = 0.2$
  - For WH: Impact parameter cut $d_0 < 0.1$ mm
  - Latest recommended smearing and efficiency corrections
  - For veto in WH use `loose++` and Forward with $p_T > 10$ GeV and $|\eta| < 4.5$. Require track isolation (except Forward)
- Muons
  - STACO(Muid) comb./tagged with $p_T > 20(25)$ GeV and $|\eta| < 2.5$ for $Z(W)$
  - Track isolation: $\sum_{tracks} / p_T < 0.1$ within $\Delta R = 0.2$
  - Impact paramter cuts $d_0 < 1(0.1)$ mm for $Z(W)$
  - Impact parameter cut against cosmics $z_0 < 10$ mm
  - Latest recommended smearing and efficiency corrections
  - For veto in WH extend to standalone, $p_T > 10$ GeV and $|\eta| < 2.7$. Require track isolation (except standalone)

Jet + E_T^{miss} Selection

- Jets
  - Anti-k_T 4 with $p_T > 25$ GeV and $|\eta| < 2.5$ "AntiKt4TopoEMJets"
  - For jet veto in WH $p_T > 20$ GeV and $|\eta| < 4.5$
  - Remove events with jets pointing to the bad FEB region
  - Pile-up: reject jets with $|JVF| < 0.75$ for jets with $|\eta| < 2.5$
  - Current JES/JER uncertainty includinh pile-up, close by and b JES
- b-tagging
  - MV1 with $w > 0.614$ ($\approx$ 70% efficiency)
    - Corrections and errors not yet available
- MET
  - MET_RefFinal out-of-the-box
  - Apply pile-up reweighting for each MC run period
  - At the moment no additional μ scaling to deal with issues due to pile-up model (pythia 8) for MC11b

Event Selection

- Common selection
  - Using WZ+jets GRL (includes b-tagging)
  - Triggers: Standard single and dilepton triggers
  - Primary vertex containing at least 3 tracks
- $ZH \rightarrow llbb$
  - Exactly 2 leptons with $76 < m_{ll} < 106$ GeV
  - Opposite charge required for muons
  - $E_T^{miss} < 50$ GeV
  - At least 2 jets(1 jet with p_T >45 GeV), exactly 2 b tagged
- $WH \rightarrow l\nu bb$ selection
  - 1 lepton and $M_T > 40$ GeV
  - $E_T^{miss} > 25$ GeV
  - Exactly 2 jets(1 jet with p_T >45 GeV) and both b tagged

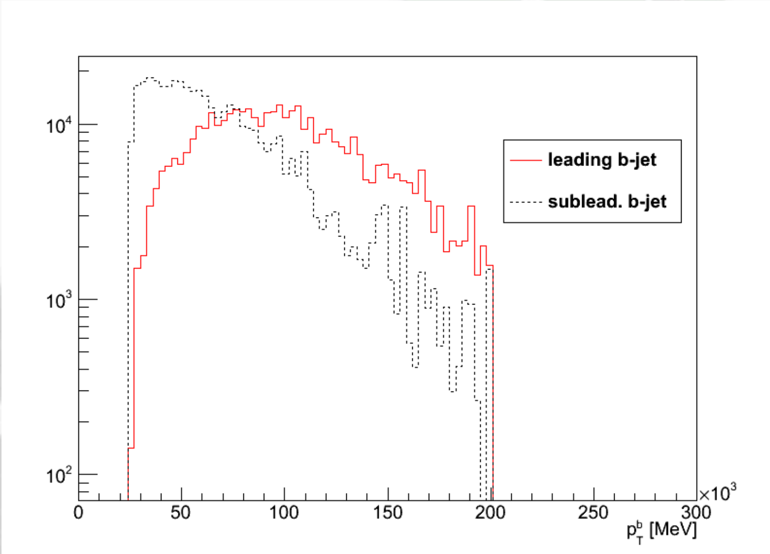
Lepton/Jet Veto Selection (WH)

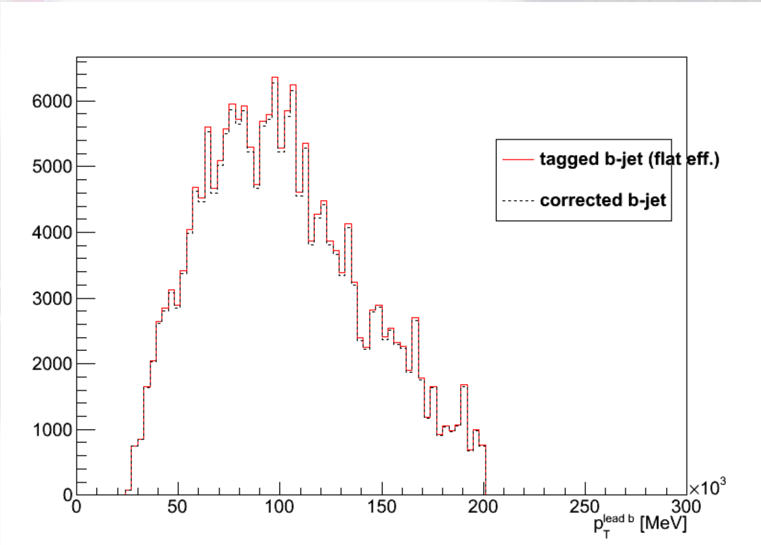
Further rejection of top. Veto jet has $p_T > 20$ GeV and $|\eta| < 4.5$. Veto lepton has wider η range than trigger electron (standalone muons, forward electrons).

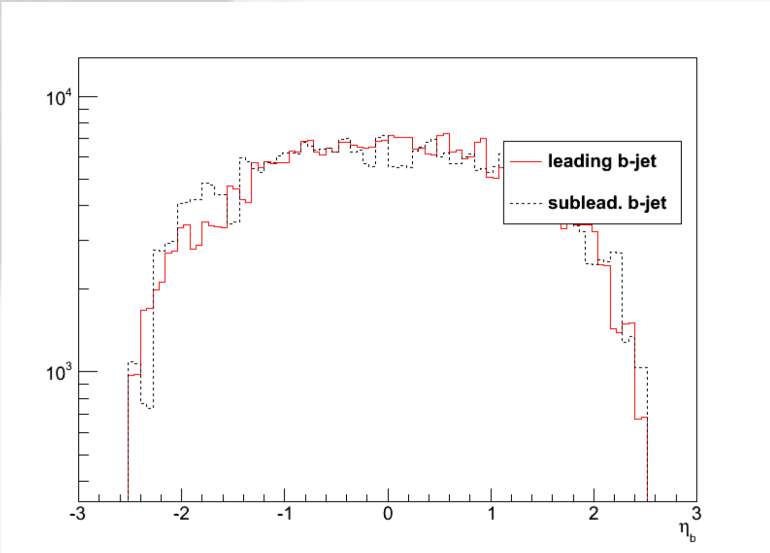
- Object overlap removal
  - if $p_T^e > 20$ GeV and $\Delta R(jet, e) < 0.4$, remove jet
  - if $p_T^e < 20$ GeV and $\Delta R(jet, e) < 0.4$, remove e
  - if $\Delta R(jet, \mu) < 0.4$, remove μ
- Remove any event with trigger lepton and
  - 1 extra lepton with $p_T > 20$ GeV
  - 1 extra *opposite sign* lepton with $p_T < 20$ GeV
  - > 1 extra leptons
- Remove any event with
  - with ≥ 3 jets with $p_T > 20$ GeV

Using different input kinematics

- Re-did some plots with b-tagged jets from W+bb and top backgrounds
- Jet pT cutoff at 200GeV





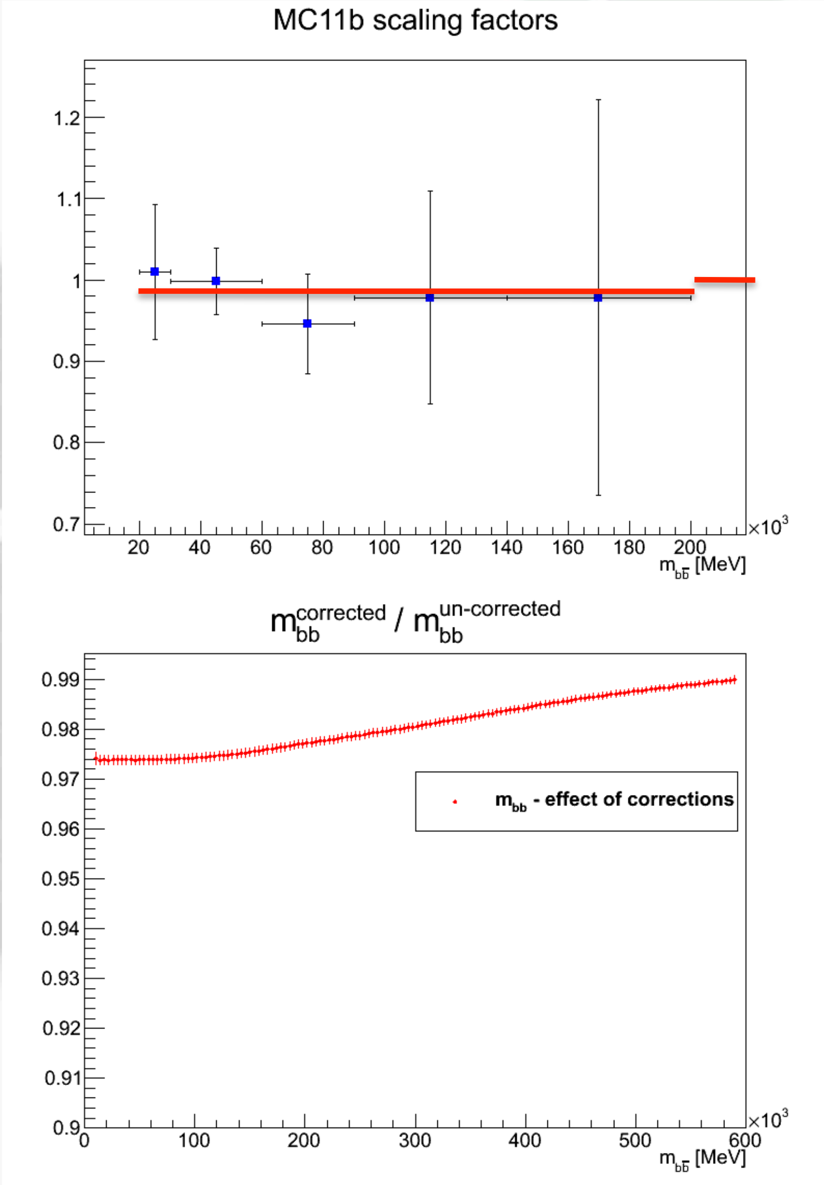


Effect of our averaging procedure

- We use the average of the scale factors (0.9865) and propagate the errors taking into account bin-to-bin correlations

- Small effect still visible (bottom right) looking at wide mass range

- But very smooth compared to the horizontal with of our signal peak



Cross checks

- If all b-tagging scale factors are set to 1 there is no effect on the mass distribution, as expected (top right)
- If they are all set to the average (0.9865) including for jets with p_T^b>200GeV, effect on mass is flat, also as expected (bottom right)