HSG5: H → bb

Ricardo Goncalo for the HSG5 group
Higgs Working Group Meeting, 10 November 2011

State of the art…

- Two channels seem possible for the CERN Council meeting:
  - WH→lνbb and ZH→llbb
- Other channels need more time:
  - ZH→ννbb, jet substructure in VH (WH→lνbb, ZH→llbb, ZH→ννbb) ttH→ttbb
- WH→lνbb and ZH→llbb:
  - Analysis: select a good W or Z boson and search Higgs in mbb spectrum
  - First results made public in EPS with $1fb^{-1}$
  - Analyses optimized for $5fb^{-1}$ in release 16

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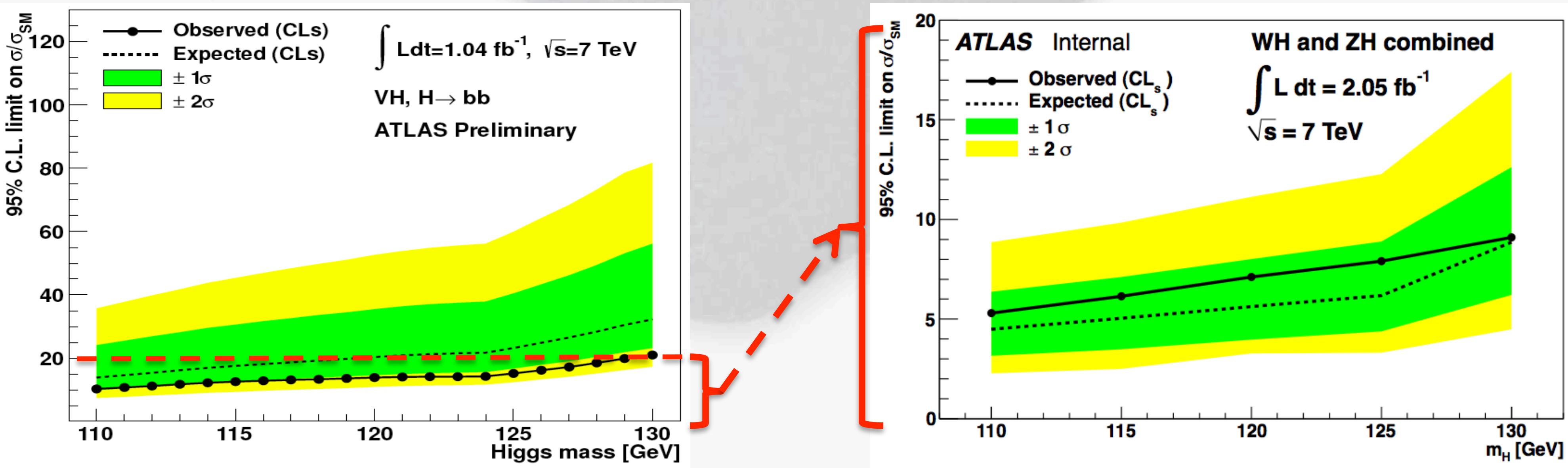

WH->lνbb and ZH->llbb Optimisation

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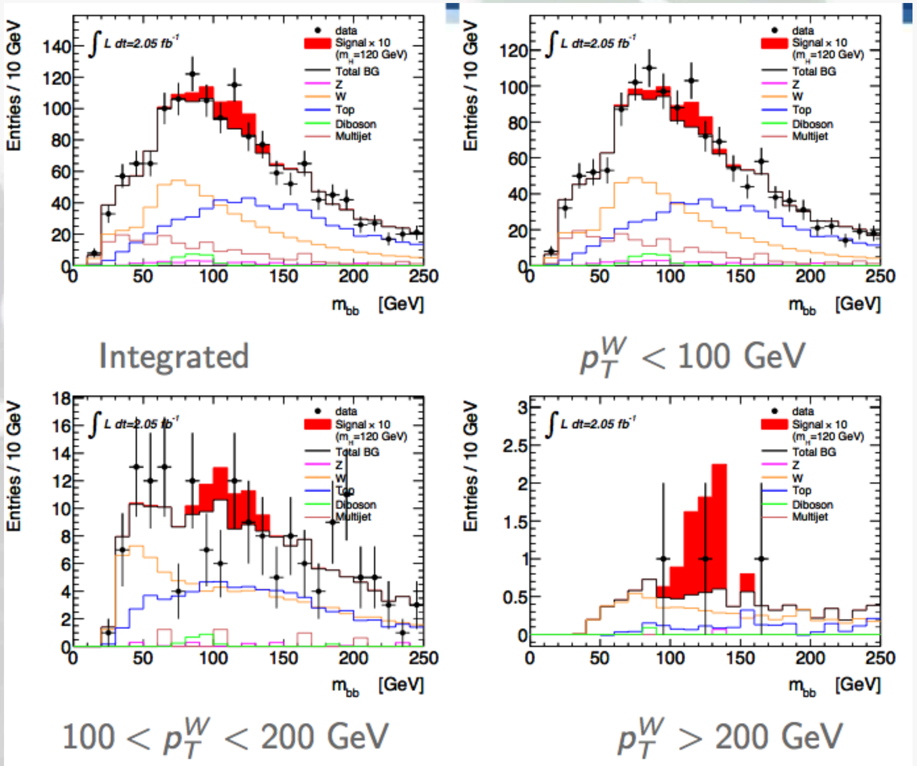
- Changes to suppress top bkgr in WH
  - Looser η and p_T cuts on additional lepton veto
  - Looser p_T cut on additional jet veto
  - Now at the same level as W+jets

- Improve efficiency and significance
  - JetNNComb instead of IP3D+SV1
  - Tuned cuts in separate p_T^W and p_T^Z bins



p_T^W [GeV]	$\Delta\phi_{jj}$	$\Delta\eta_{jj}$	$\Delta\phi_{WH}$
< 50	> 1.5	< 2.4	> 2
$50 < p_T^W < 100$	$0.9 < \Delta\phi_{jj} < 3$	< 2.4	> 2.6
$100 < p_T^W < 200$	< 3.0	< 2.3	> 2.7
> 200	> 1.25	< 1.8	> 2.8

p_T^Z [GeV]	$\Delta\phi_{jj}$	$\Delta\eta_{jj}$	$\Delta\phi_{ZH}$
< 50	> 2	< 2	> 2
$50 < p_T^Z < 100$	$1.5 < \Delta\phi_{jj} < 2.75$	< 2	> 2.5
> 100	< 1.5	< 2	> 2.5

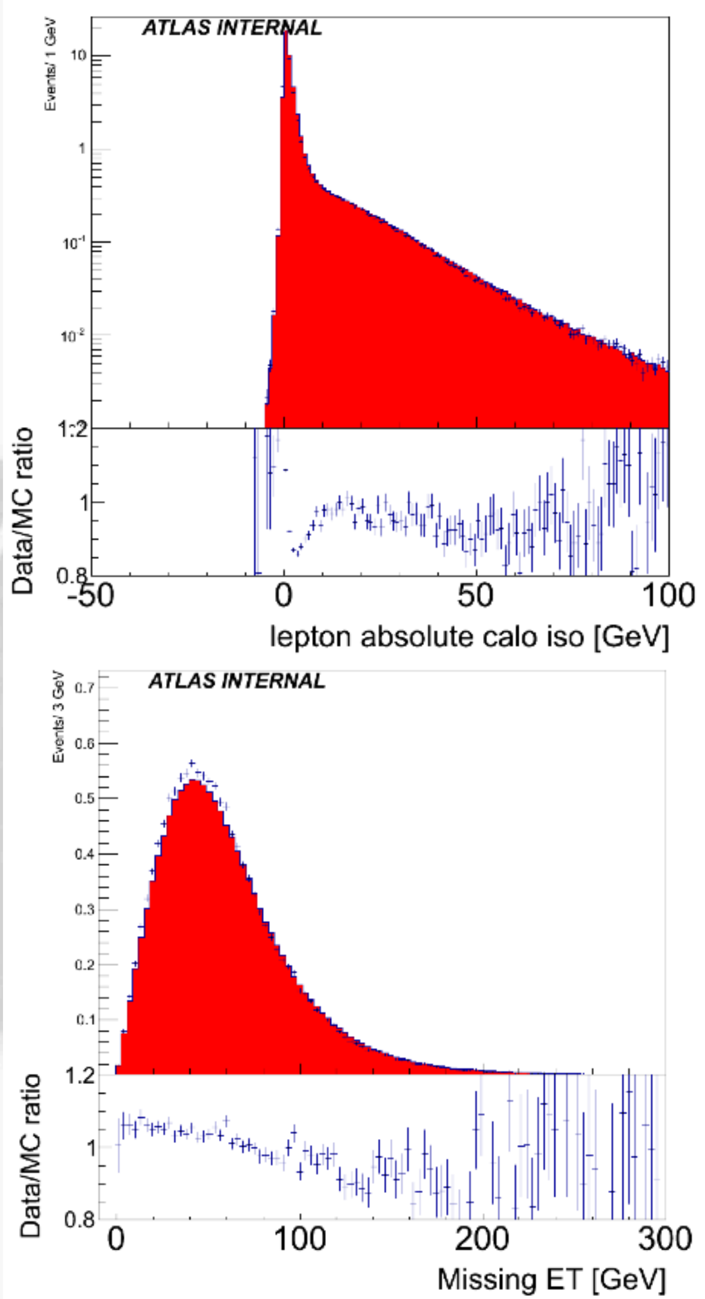
Stumbling blocks…

- Monte Carlo!!! ☹
  – We don't have the rel.17 MC yet
  – It's not yet clear if we'll have it in time
  – H->bb signal in plans with priority 1 (end of November)
  – Many backgrounds have priority 0

- Main concern is W+h.f.
  – Should be solved now with Atlfast-II
  – Validated this week and looks ok for our purposes

- AFII/FS differences from cut flow:
  – 0.5% in muon isolation
  – 1% in electron ID
  – 2% in electron calo isolation
  – 5% in MET below ≈80 GeV
  – Small differences in jet energy scale

Giacinto Piacquadio, Chiara Debenedetti, Heather Gray



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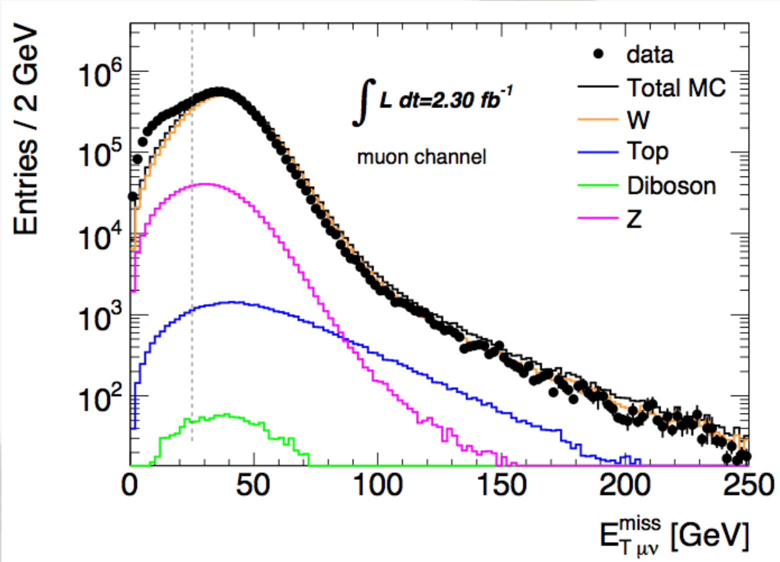
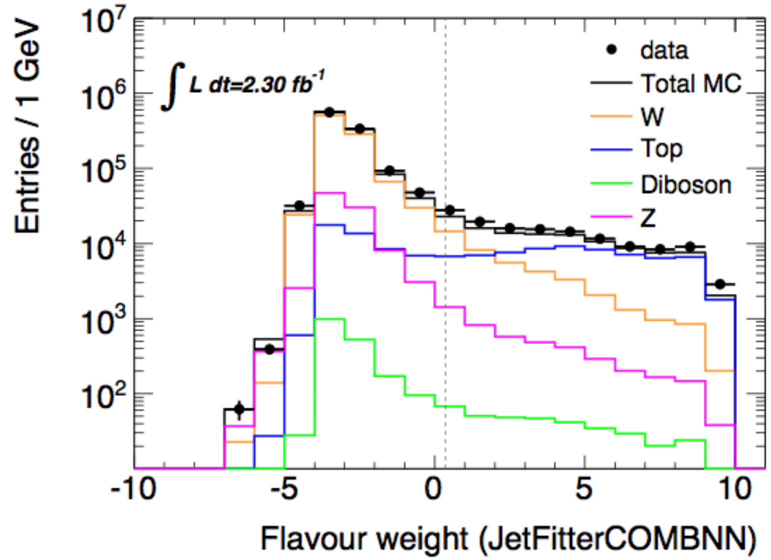
Stumbling blocks…

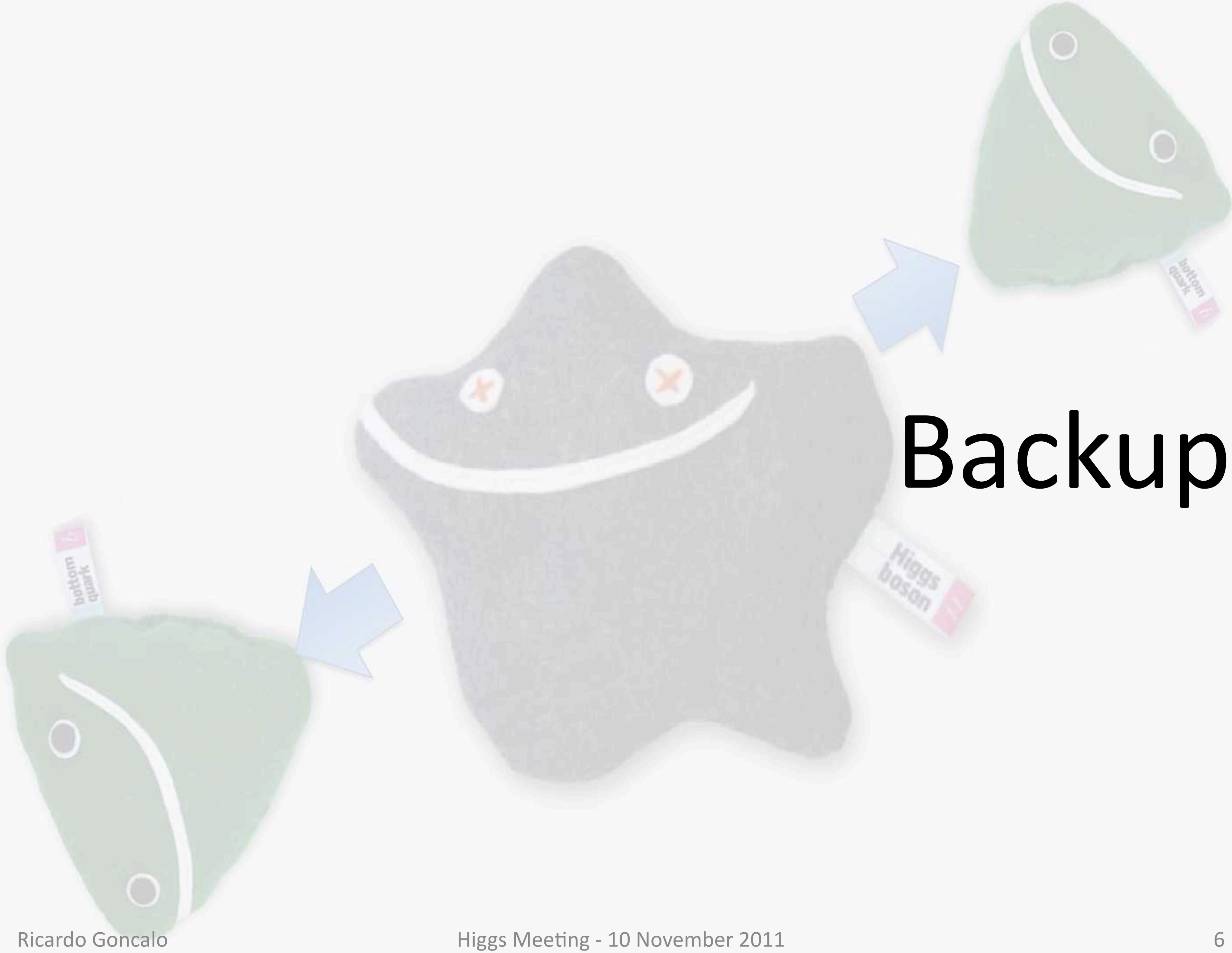
- Scaling factors, fake rates, etc
  - Expect preliminary values from H.F.-tagging group
  - Hope to have best possible information from jets and MET
- Data/MC agreement in all control variables not yet seen
  - But already pretty good
- A broken crystal ball…
  - What else will happen?
  - Not much time to let analysis mature
  - But very good starting point!



$W \rightarrow \mu\nu$



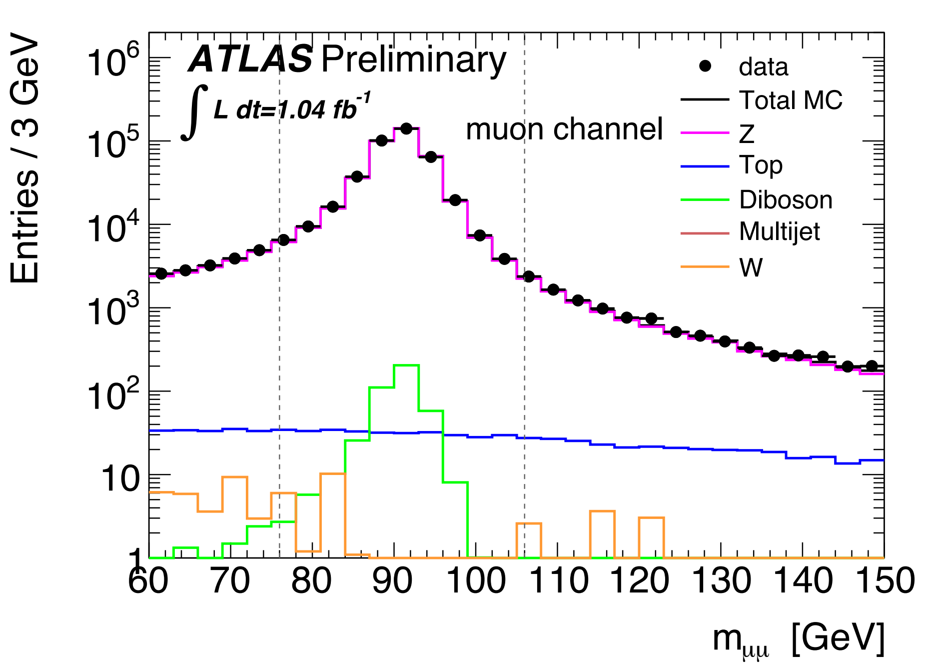
Tagger weight, $N_{jet} >= 2$

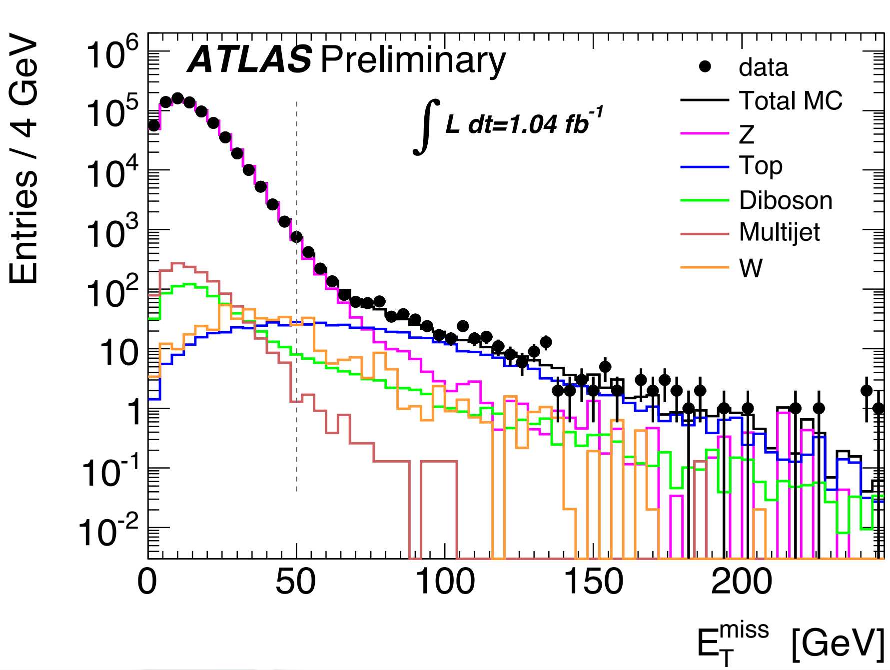


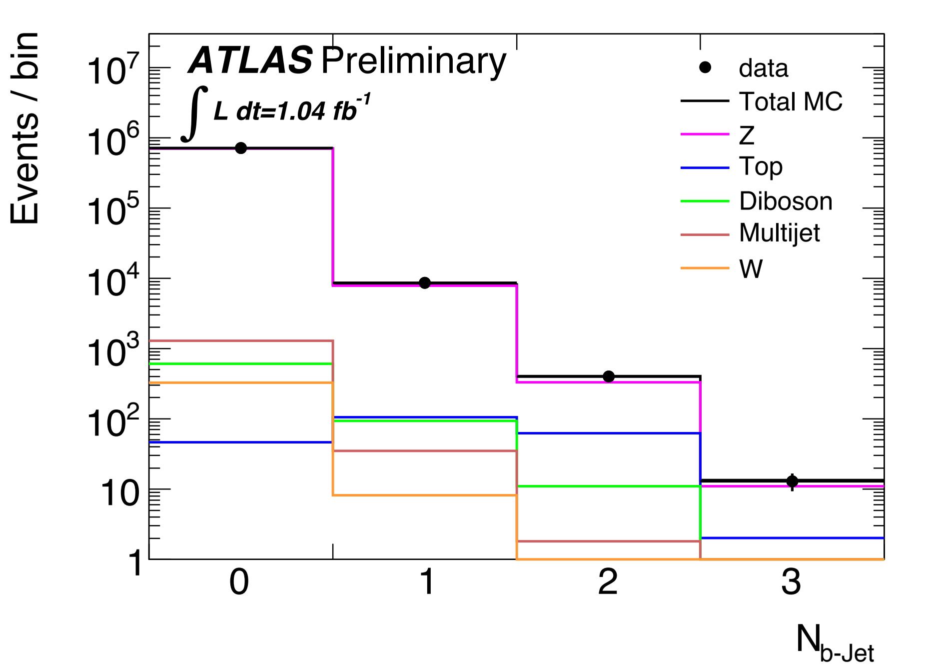
Backup

ZH→llbb Selection

- Trigger:
  - e (p_T^e>20GeV) or μ (p_T^μ>18GeV)
  - 2e/2μ trigger (p_T>12GeV)
- Exactly 2 leptons p_T > 20GeV
  - Opposite charge for μ
- Z mass cut: 76 < m_{ll} < 106 GeV
- E_T^{miss} < 50GeV
- Two leading jets b tagged

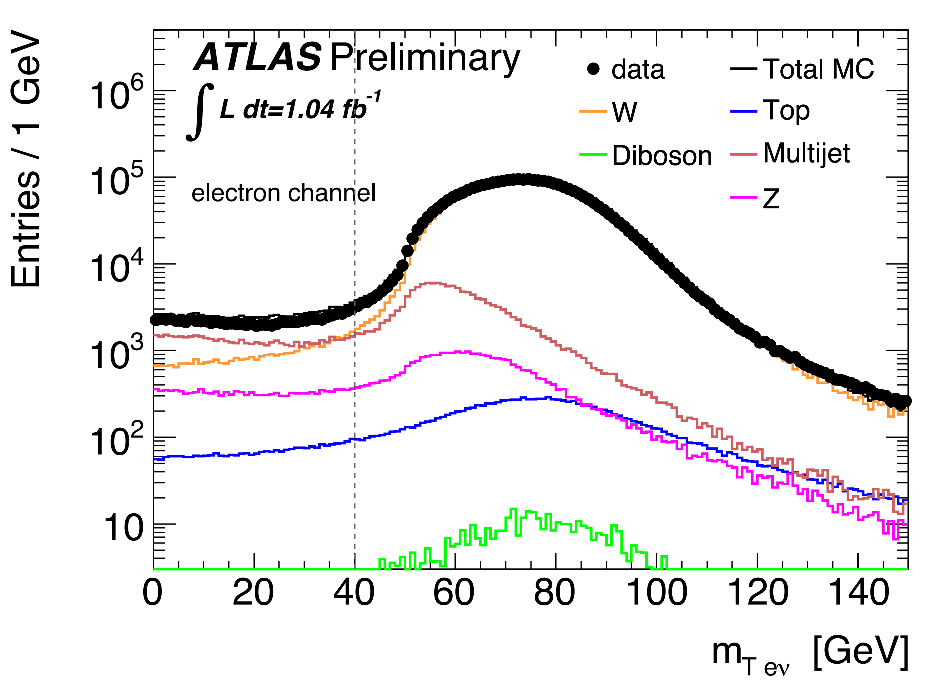


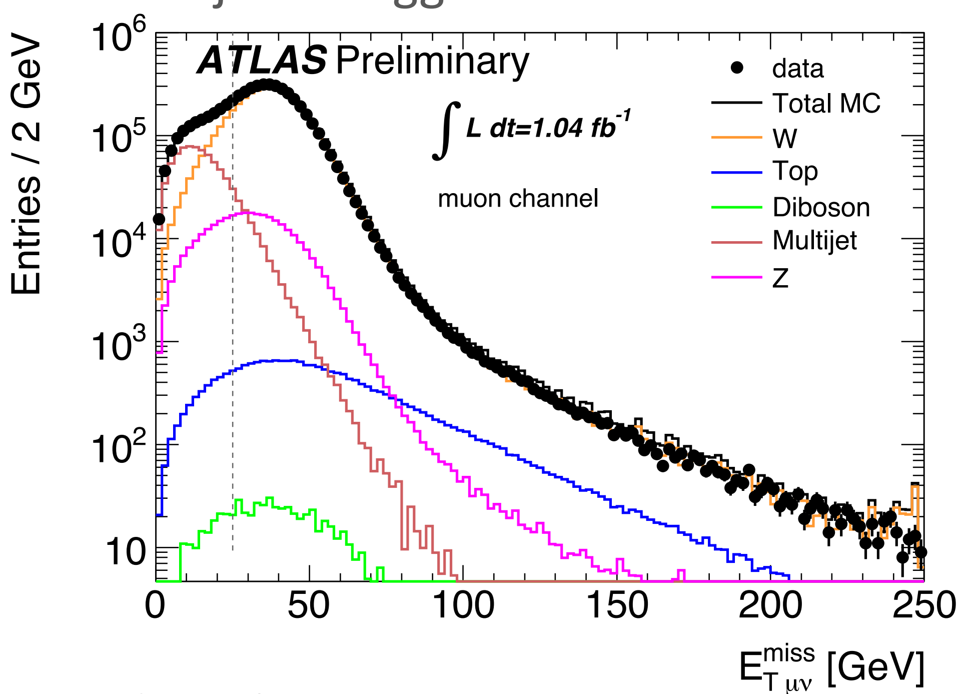


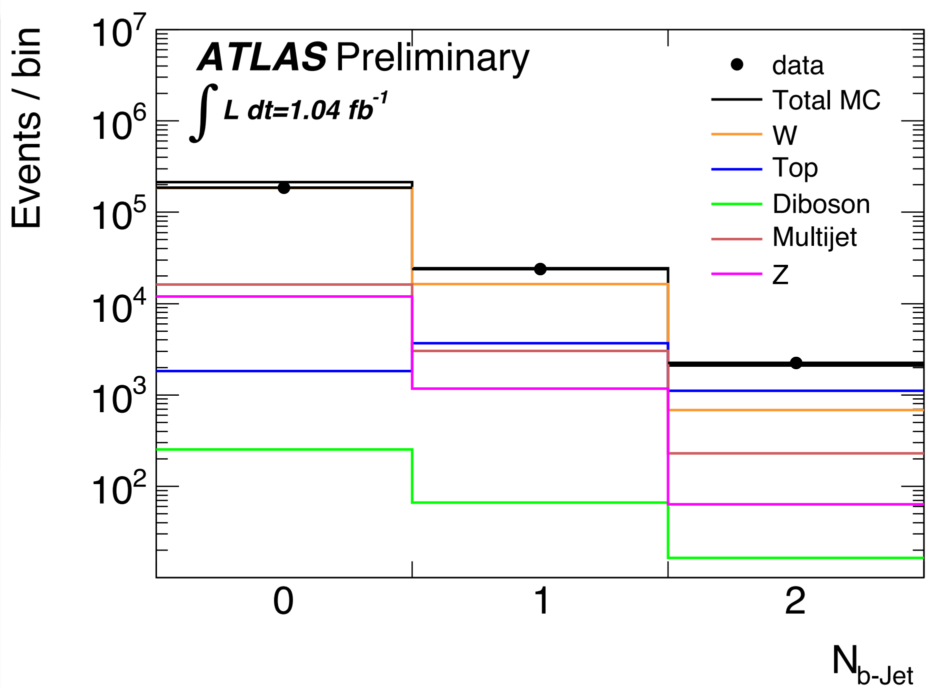


WH→lνbb Selection

- Trigger: e (p_T^e>20GeV) or μ (p_T^μ>18GeV)
- Exactly 1 lepton – p_T > 25GeV
- $M_T = \sqrt{2 p_T^l p_T^\nu (1 - \cos \Delta\phi_{l\nu})} > 40$ GeV
- E_T^{miss} > 25GeV
- Exactly 2 jets (anti-k_T 0.4; E_T > 25GeV) to reduce top background
- Both jets b tagged

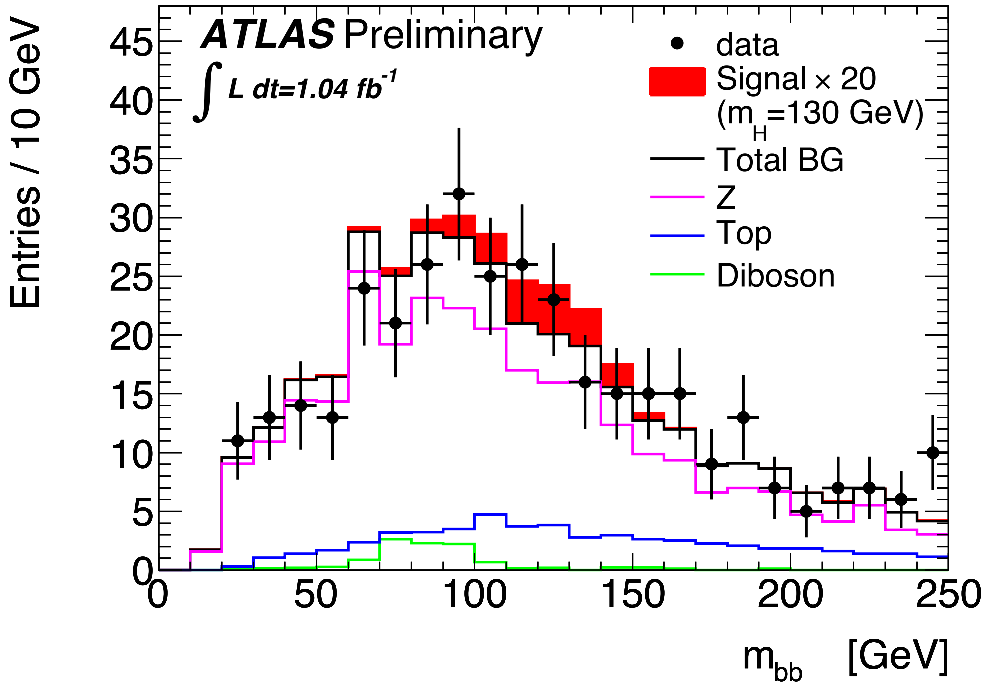


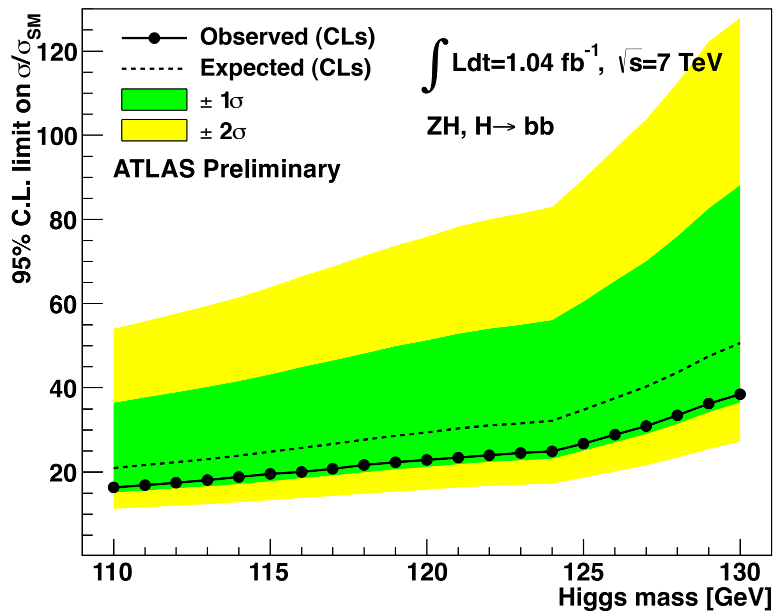




ZH→llbb

- Good description of the background
- No excess observed
- Single-channel exclusion of ≈20x Standard Model





Source	expected events		(stat.)		(sys.)
Z+jets	261.0	±	7.8	±	24.6
Top-quark	52.0	±	1.3	±	10.6
Multijet	1.4	±	0.4	±	1.4
ZZ	9.2	±	1.1	±	2.3
WZ	1.1	±	0.3	±	0.3
Total background	324.8	±	8.0	±	27.9
Data	329				
Signal m_H = 110 GeV	2.22	±	0.09	±	0.43
Signal m_H = 115 GeV	1.91	±	0.07	±	0.38
Signal m_H = 120 GeV	1.58	±	0.06	±	0.32
Signal m_H = 125 GeV	1.44	±	0.05	±	0.28
Signal m_H = 130 GeV	1.02	±	0.04	±	0.20

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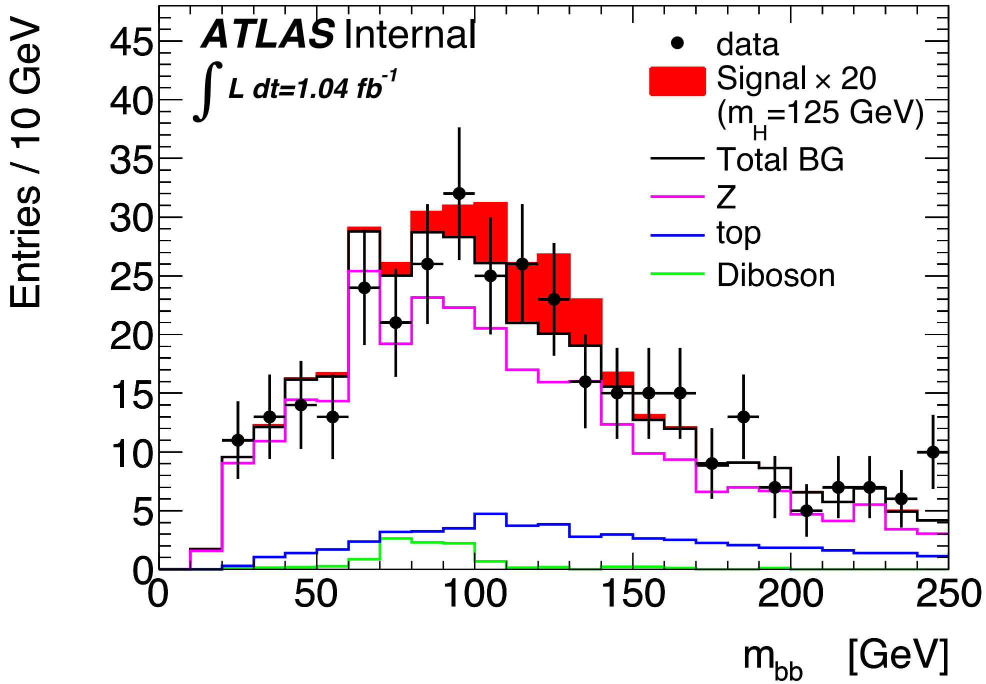

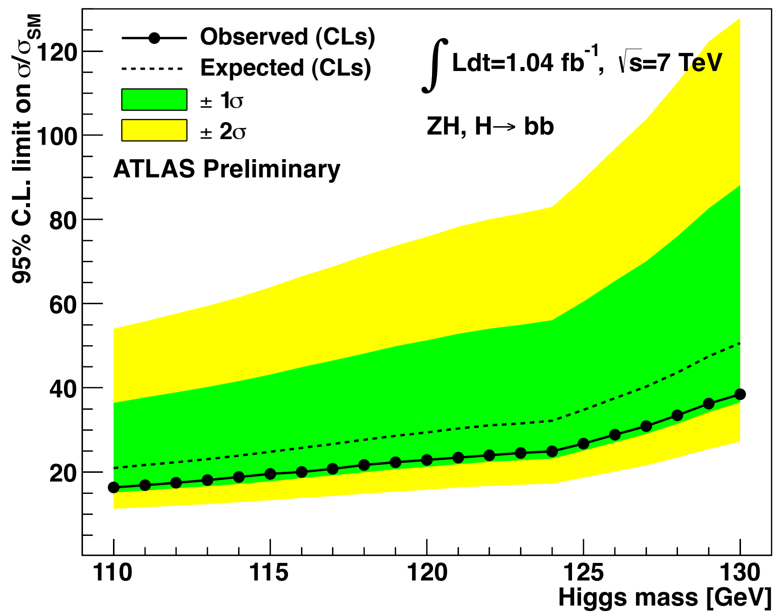

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ATLAS-CMS comparisons

- Jonas and Jike have emulated CMS's cuts in WH->lvbb and ZH->vvbb
- Differences not yet clear – need to continue to pursue this
- Similar significances in WH ->lvbb when applying mass window cut
  - But very different event numbers – by factor 10-100 depending on channel
- CMS seems to get a lower QCD background than us in ZH->vvbb

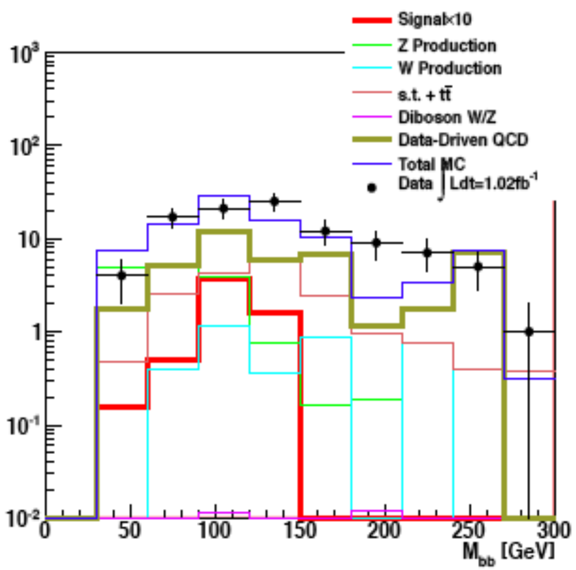
WH->lvbb

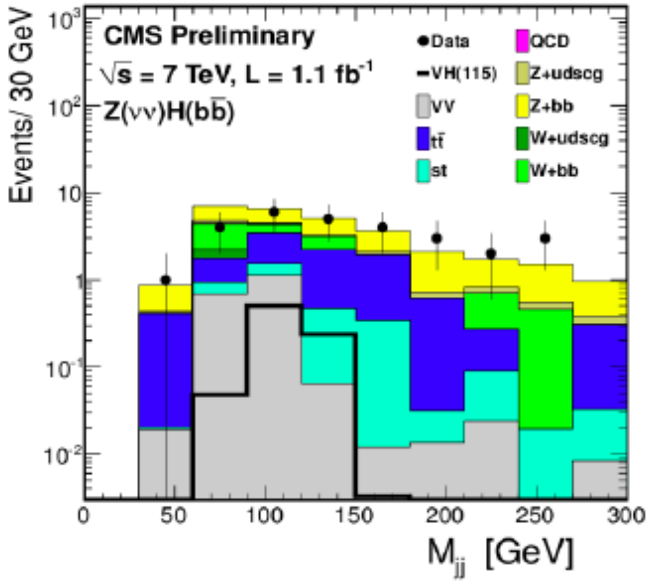
S/sqrt(B) for 40<m(bb)/GeV<240

	ATLAS-EPS	CMS-like
WH_115	0.163686	0.157101
WH_120	0.148339	0.116313
WH_130	0.0925769	0.0926334

S/sqrt(B) for sliding window (30 GeV)

	ATLAS-EPS	CMS-like
WH_115	0.198323	0.260037
WH_120	0.174354	0.213981
WH_130	0.0975579	0.148665

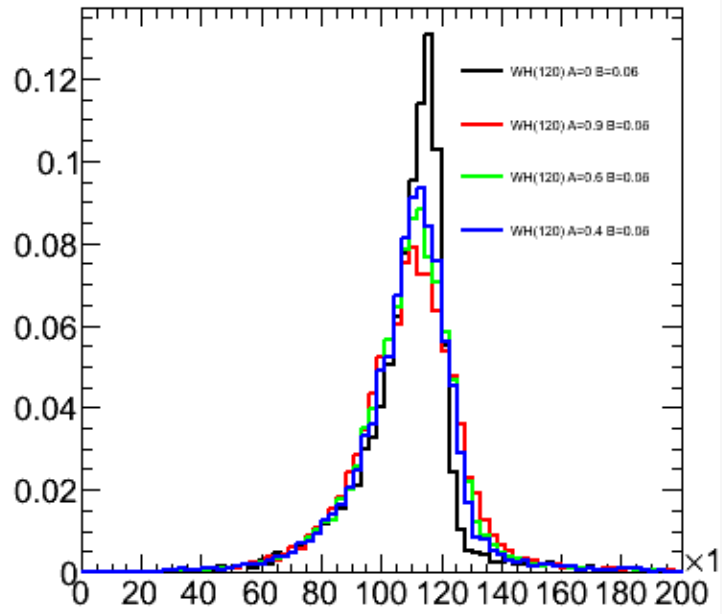


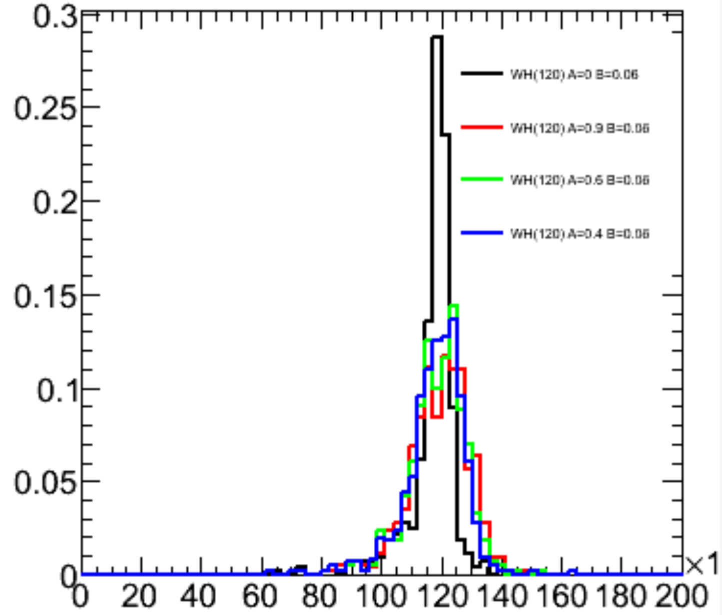


Mass Range	Mine : $90GeV < M_{bb} < 150GeV$	CMS : $100GeV < M_{bb} < 130GeV$
$S/\sqrt{S+B}$	$0.53/\sqrt{0.53+58.60} = 0.07$	$0.59/\sqrt{0.59+4.79} = 0.25$

Performance studies

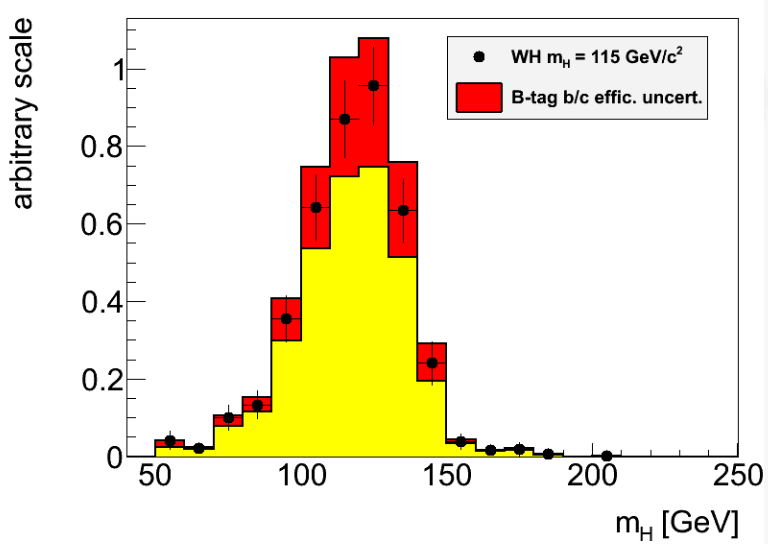
- Main systematics are jet and b-tagging related
- Current tasks listed in [Wiki]
- More questions than answers at the moment, but pursuing several threads:
- Jet resolution:
  - We seem to be affected by out-of-cone losses
  - Will try different jets
- B-tagging:
  - Find how much improvement needed to reduce syst
  - Improve MC statistics term of b-tagging uncertainty with AFII – requesting some AFII validation samples
  - Differences between hadronic and semileptonic b-jets

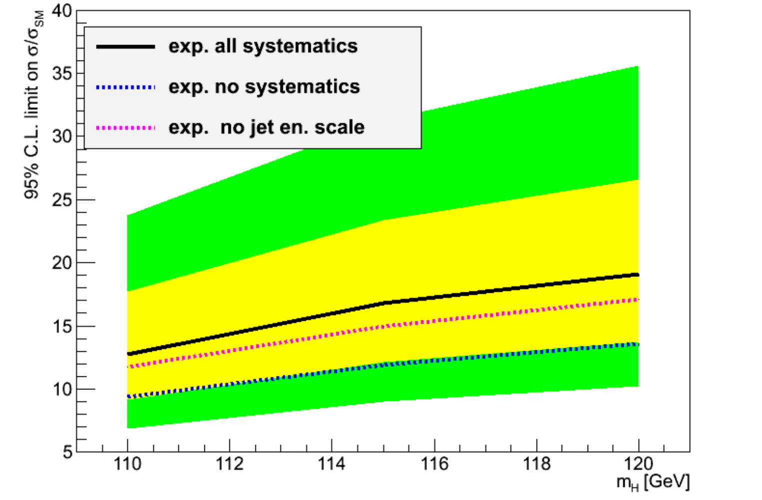




H→bb – Reconstruction Performance

- Main limitations from jet reconstruction and b-tagging uncertainties
- Try to improve b-tagging efficiency/ fake rate uncertainty:
  - Dominant uncertainty on signal yield in EPS analyses
- Try to optimize di-jet mass resolution:
  - A sharper peak improves analysis sensitivity (10% width reduction ≈4% limit improvement)
- Try to reduce jet energy scale uncertainty:
  - Large effect in limit through changes in m_{bb} shape





Backup

- Replaced signal with fitted Gaussian to manipulate signal width
- Estimated improvement in limits ($1fb^{-1}$) with reduced signal width
- Reduction to 80% gives 8% improved limits (magenta line, bottom left)