H->bb Plans

Higgs Subconveners weekly meeting, 17 October 2011

Summary of Plans

- For CERN Council meeting:
  - Update results on WH->lνbb and ZH->llbb with optimized analyses
  - Produce results on ZH->ννbb

- In parallel:
  - VH boosted channels: WH->lνbb, ZH->llbb, and ZH->ννbb
    - Aim to produce results for Moriond 2012
    - Related to this: analyses of boosted Z->bb and WZ/ZZ->lljj/llbb
  - Other channels – won't go into these today:
    - Work on VBF H->bb – maybe results for Moriond
    - Gluon-fusion H->bb
    - Boosted Higgs in ttH
    - Inclusive ttH analysis
    - Production of γbb

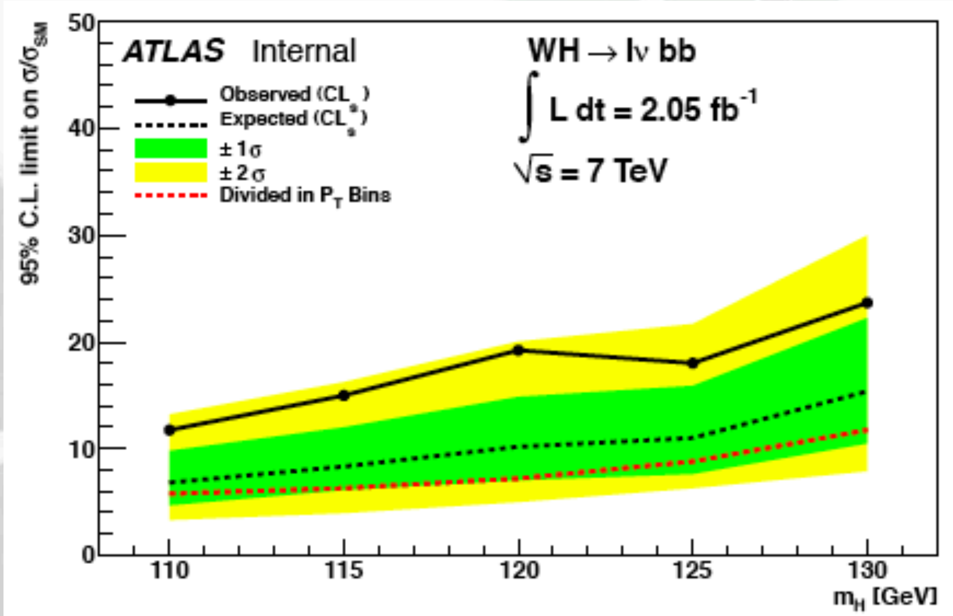
- Publication(s?):
  - Plan is to have a paper on WH->lνbb, ZH->llbb and ZH->ννbb
  - Draft should be ready to be turned into CONF note for CERN council meeting
  - Better results with final rel.17 performance for Moriond
  - Add boosted analyses for Moriond

WH->lνbb and ZH->llbb

- EPS analyses updated in rel.16 for $2fb^{-1}$:
  - Much improved top rejection in WH analysis:
    - Tighten lepton veto – as in HSG2: pT > 7 GeV and $|\eta| < 4.5$
    - Reduced tt by 50%, for signal efficiency of 92%.
  - Use JetFitterNNComb flavour tag (70% eff. w > 0.35)
  - Tighten extra jet veto: $p_T > 15$ GeV
  - Gives 70%(40%) signal(background) efficiency

- Separated into categories of p_T^W and p_T^Z:
  - $p_T^W < 100$GeV; $100 < p_T^W < 200$ GeV; $p_T^W > 200$ GeV
  - $p_T^Z < 50$GeV; $50 < p_T^Z < 100$ GeV; $p_T^Z > 100$ GeV

- Latest results with rel.16 are very nice:
- For m_H=115GeV and $2fb^{-1}$:
  - WH: 6.3 x SM with p_T^W bins / 8.4 x SM without (all syst.)
  - ZH: 8.3 x SM with p_T^W bins / 11.4 x SM without (no syst)

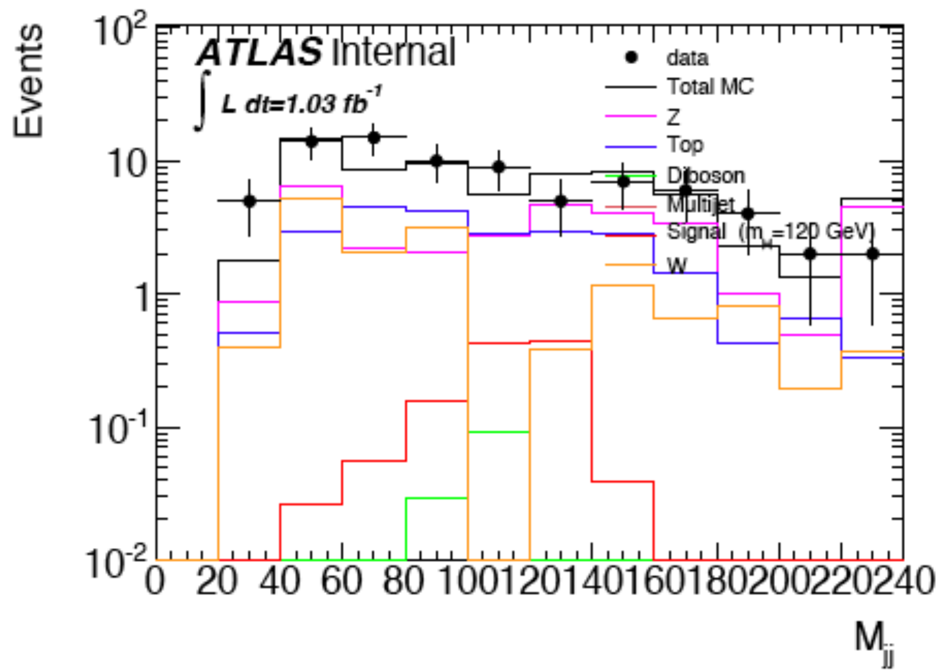


- Main groups behind analysis are Liverpool and Birmingham (Andy Mehta and Paul Thompson)
- Jonas Will (LMU) starts to have confirmation analysis in shape
- Jonas also investigated ATLAS-CMS differences, but not yet clear

Plans for ZH->ννbb

- Perhaps CMS's best channel
  - We should be able to do just as well
- Two groups contributing so far and more interested:
  - Academia Sinica: Jike Wang, David Jamin, Song-Ming Wang
  - Liverpool: Matthew Jackson (Andy Mehta's student)
  - Interest expressed by CPPM Marseille and IFAE
  - Should soon have a brainstorming session to optimally join various analyses – letting things evolve for the moment
- No huge uncertainties in analysis
  - Seems feasible to produce results for December CERN Council meeting
- Should make sure we have the necessary MC samples

- Ongoing work:
  - Optimizing analysis cuts
  - Looking for differences wrt CMS
- Analyses start to look ok…
- Angular cuts to reduce QCD:
  - $\Delta\phi(Z,H) > 2.9$
  - $\Delta\phi(MET,ClosestJet) > 1.5$



ATLAS-CMS comparisons

- Jonas and Jike have emulated CMS's cuts in WH->lvbb and ZH->vvbb
- Differences not yet clear – need to insist on 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

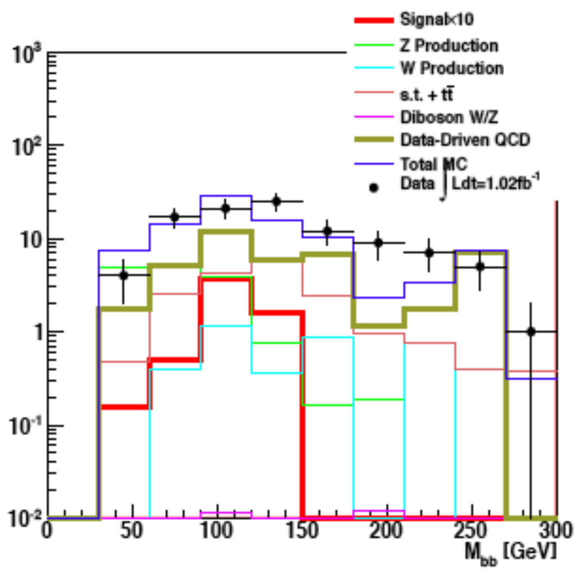
WH->lvbb

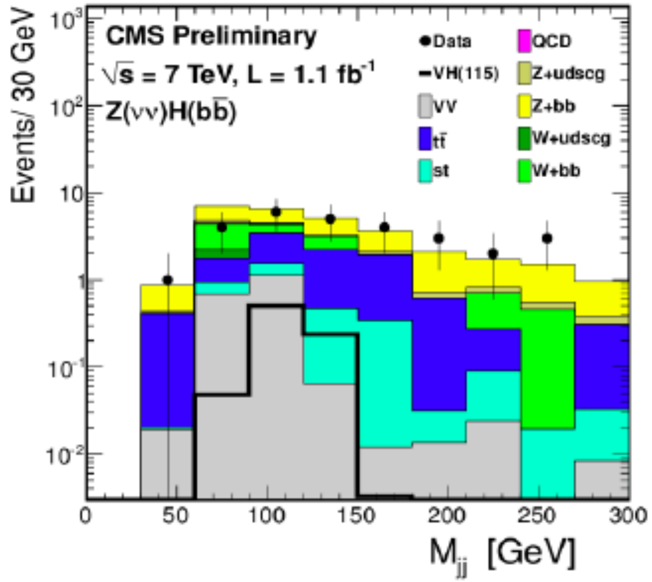
S/sqrt(B) for 40<m(bb)/GeV<240

	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





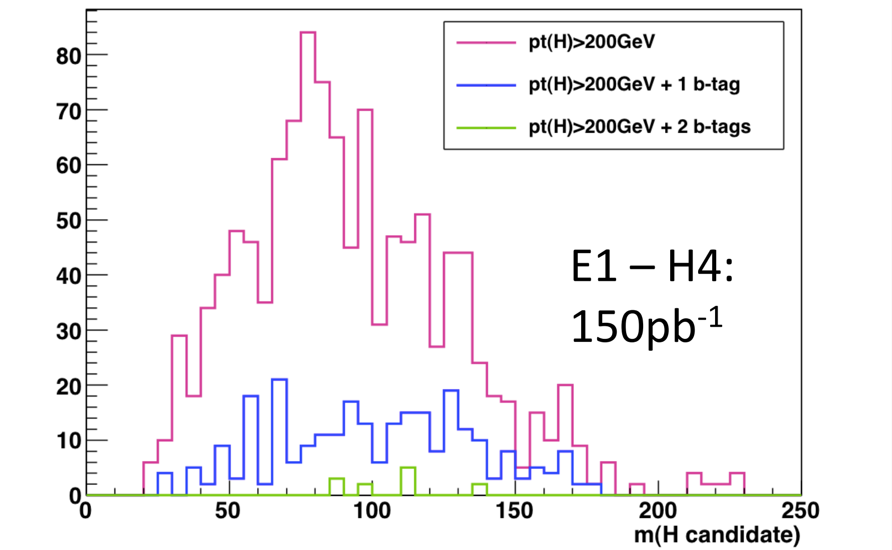
Mass Range	Mine : $90GeV < M_{bb} < 150GeV$	CMS : $100GeV < M_{bb} < 130GeV$
$S/\sqrt{S+B}$	$0.53/\sqrt{0.53+58.60} = 0.07$	$0.59/\sqrt{0.59+4.79} = 0.25$

Boosted VH

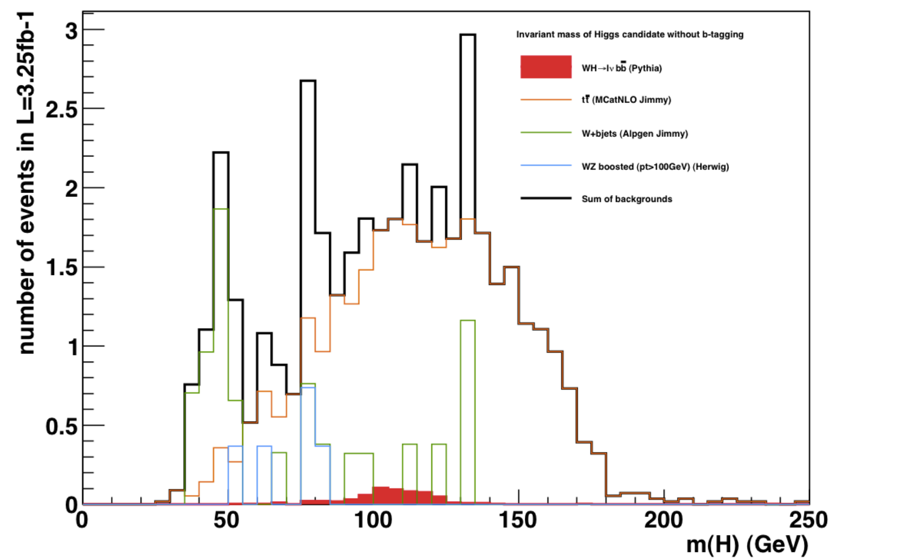
- These channels raise more questions…
  - New technique needs to be well understood and proven
- But should bring us very good sensitivity in the medium term

- My perception at present is that we should not aim for earlier than Moriond for this channel
  - But healthy number of people involved and no reason to not aim for Moriond publication

- Main groups interested are UCL and Edinburgh – starting to work more closely together
- UCL concentrating on SM analyses:
  - Ben Cooper – boosted Z->jj/bb
  - Ilektra Christidi – b-tagging in boosted bb
  - Gavin Hesketh – boosted WH->lljj/llbb
  - Adam Davison – jet substructure performance
- Edinburgh contributing in DPD development and VH analysis:
  - Robert Harrington – D3PD and skimming
  - Wahid Bhimji, Chiara Debenedetti, Brendan O'Brien – VH analysis

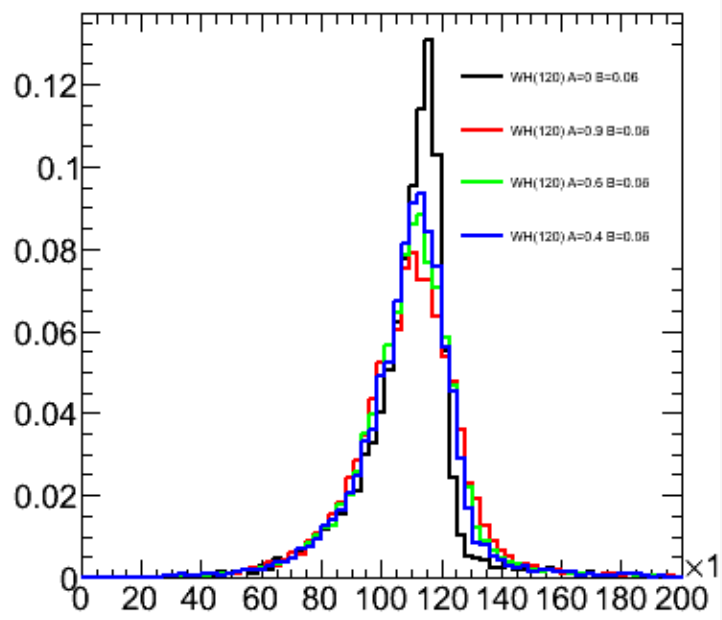


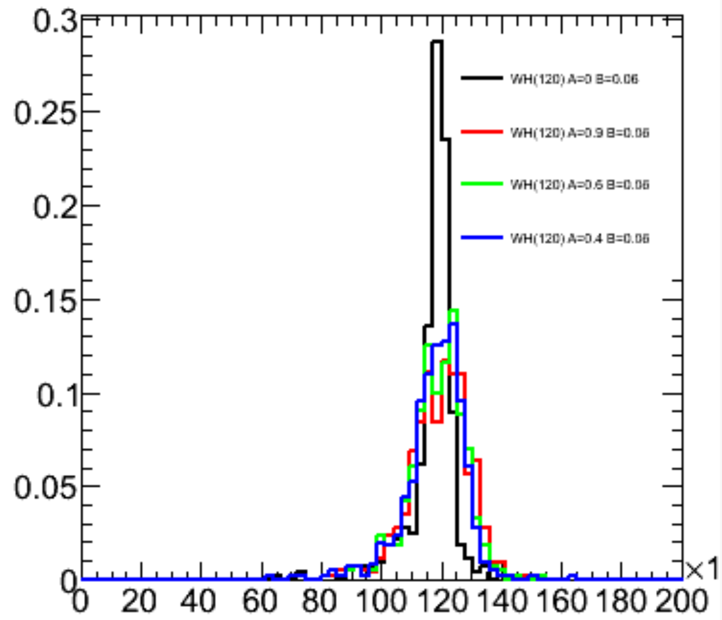
MC only

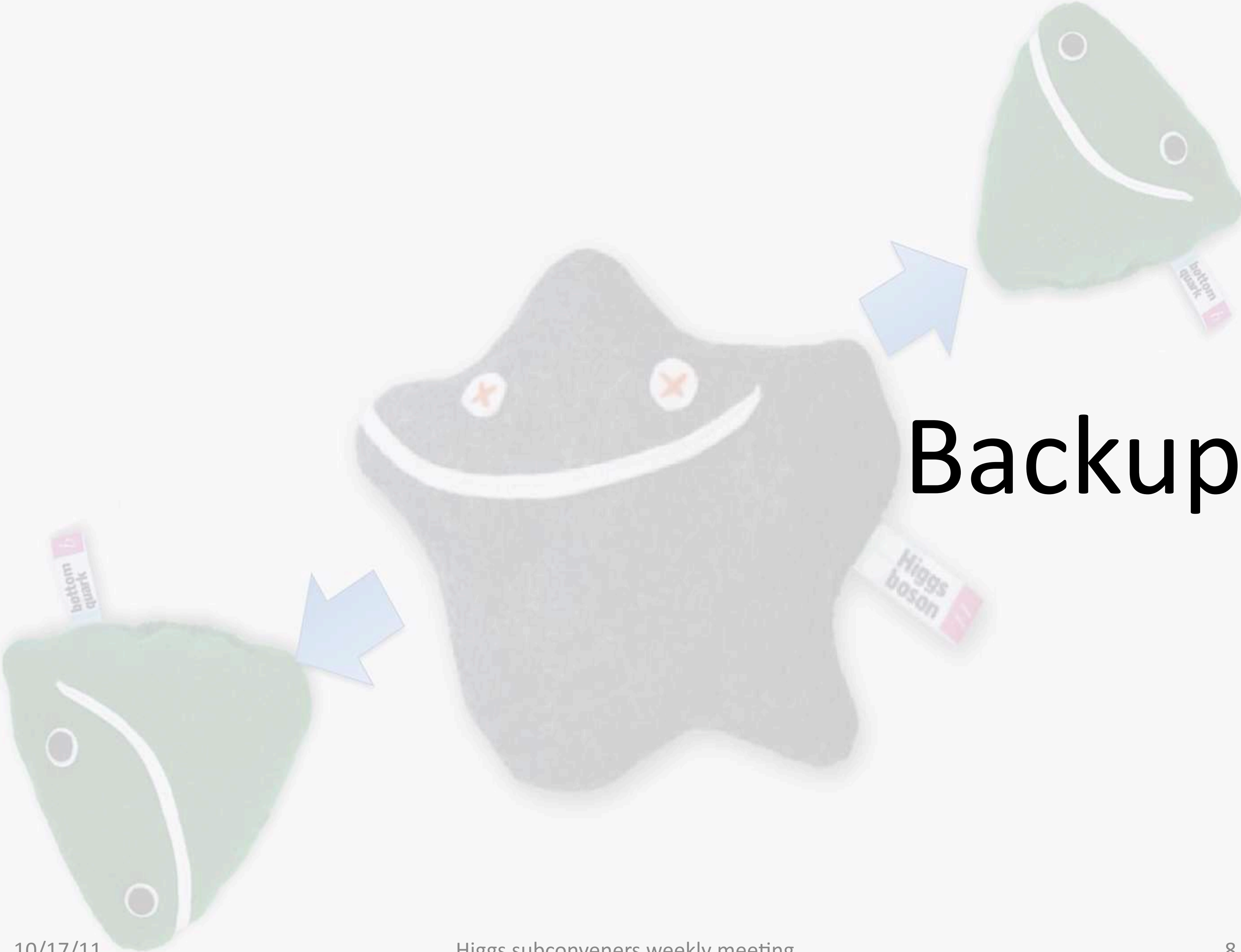


Performance studies

- Started interacting with jet group in SLAC hadronic workshop
- 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 (Giacinto Piacquadio, IFAE):
    - We seem to be affected by out-of-cone losses
    - Will try different jets
  - B-tagging:
    - Find how much improvement is needed to reduce syst
    - Improve MC statistics term of b-tagging uncertainty with AFII (Eric Ouellette (unconfirmed), Ricardo Goncalo) – requesting some AFII validation samples
    - Differences between hadronic and semileptonic b-jets
  - And will continue to interact with CP groups as much as possible to get good performance







Backup

HSG5 D3PD Status

- New stream for gamma+bb:
  - Selection modified to loosen cuts for gamma+bb
- Z->bb:
  - Some changes to HighPtTracks mplemented by Ilektra:
    - Lowered pT cut, stored more track info
    - Not yet validated
  - Adding b-tagging info and more changes to D3PD, will privately produce small validation samples for tests
- WH->lnubb: Validated by Edinburgh
- WH stream ready to go to DPD train!
  - Means getting your D3PDs for new data with no effort…
- **ZH analyses need to check Skim selections before adding this to DPD train!**

Output Skim	#events	Size
HSG5WH	5.5 M	340 GB
HSG5ZHLL	5.5 M	340 GB
HSG5ZHMET	4.8 M	240 GB
HSG5ZBB	8 M	480 GB
Total	24 M	1.4 TB

Input Stream	Period	#events	Size
JetTauEtmiss	E	8,588,376	1.27 TB
Muons	E	6,182,165	0.89 TB
Egamma	E	8,157,991	1.01 TB
JetTauEtmiss	H	37,748,640	5.51 TB
Muons	H	28,367,693	3.99 TB
Egamma	H	29,506,835	3.56 TB
Total	E+H	118,551,700	16.2 TB

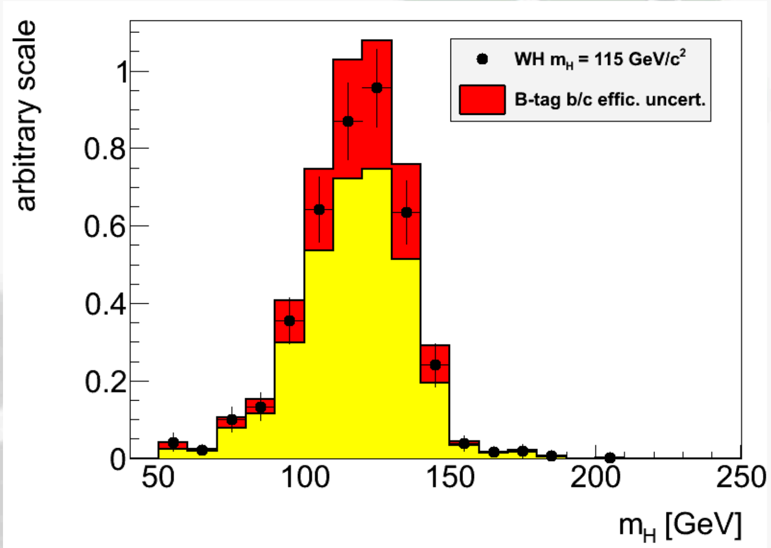
H→bb – Reconstruction Performance

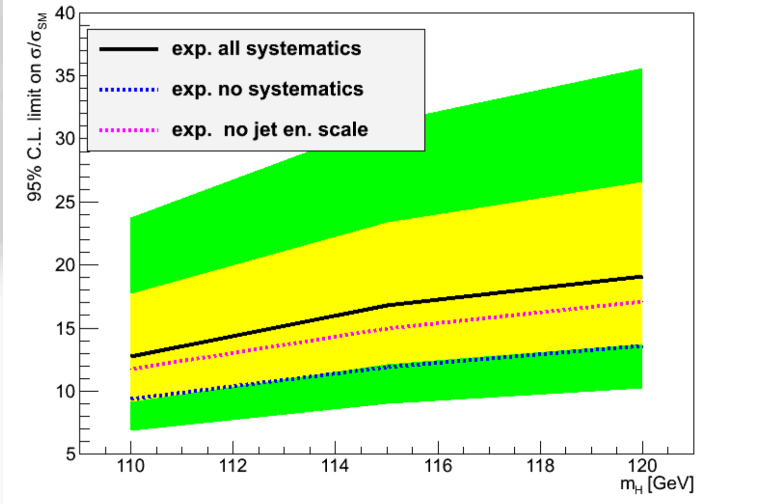
- Main limitations from jet reconstruction and b-tagging uncertainties

- 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)

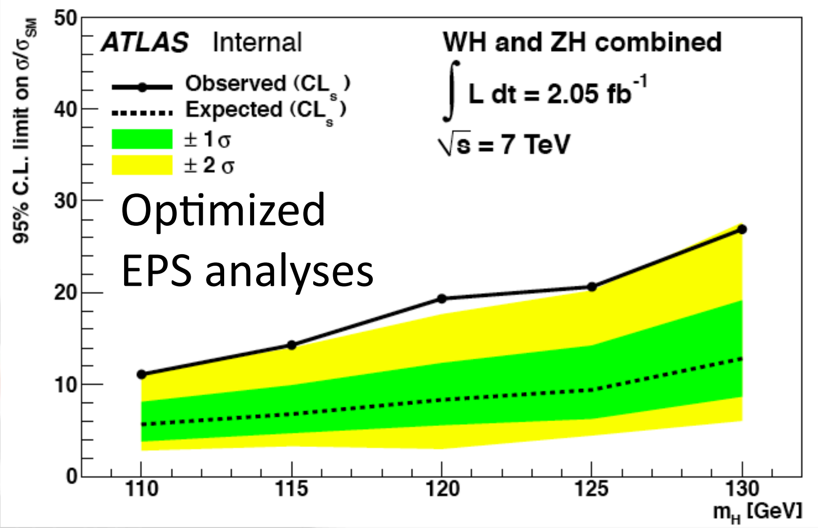
- Try to reduce jet energy scale uncertainty:
  - Large effect in limit through changes in m_{bb} shape



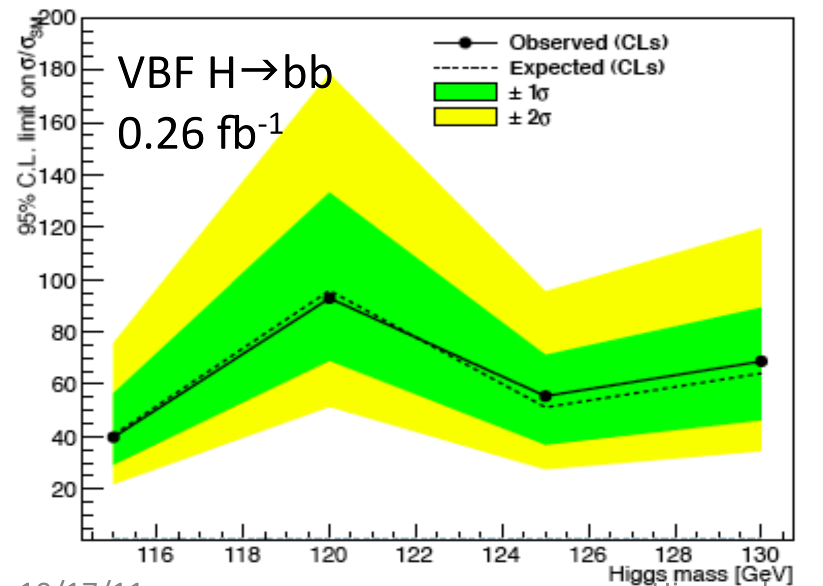


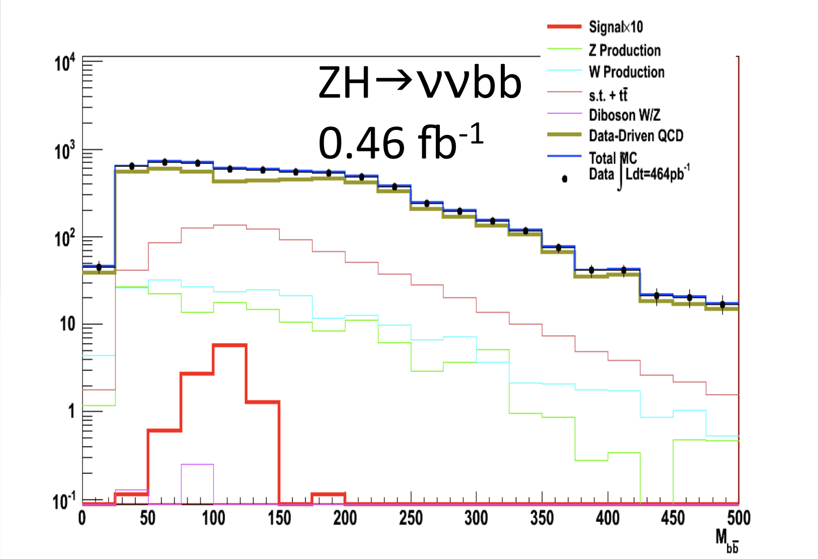
H→bb – Recent Highlights

- Update and optimization of WH→lνbb and ZH→llbb analyses with $2fb^{-1}$ (r.16)
  - Much reduced top background in WH
- First results appearing from other analyses: ZH→ννbb, boosted Z, VBF,…
- New ideas being tried: e.g. exploiting kinematics of transition region between low and high Higgs p_T



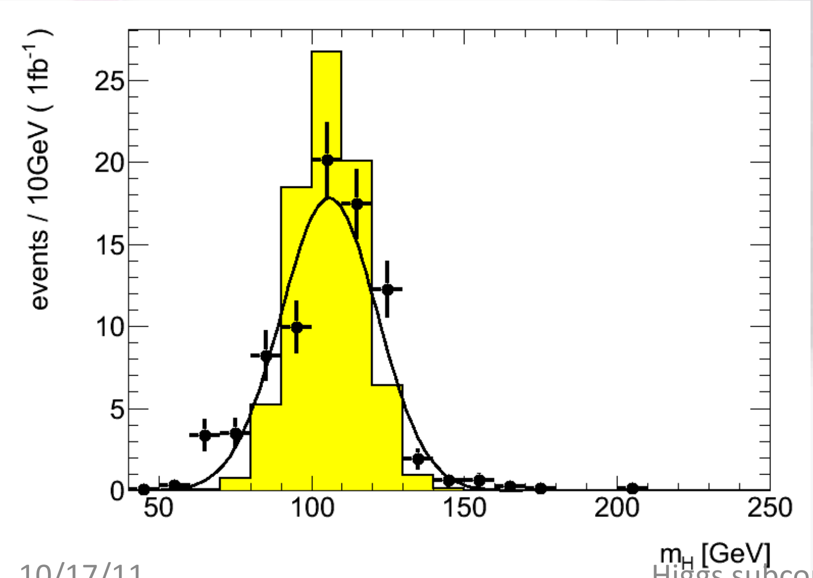
Rough first estimate!

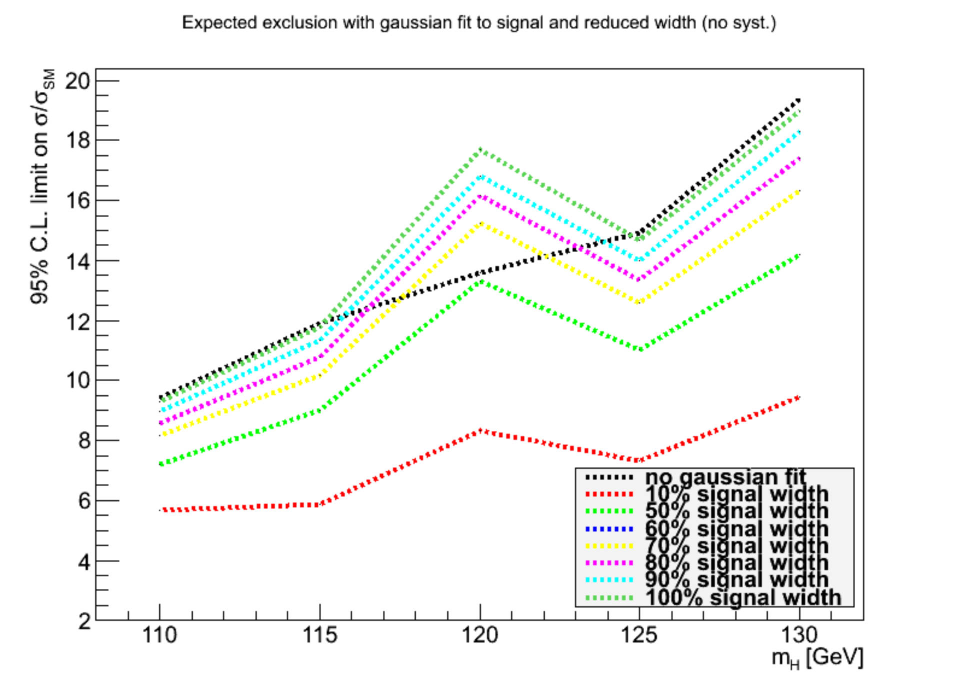


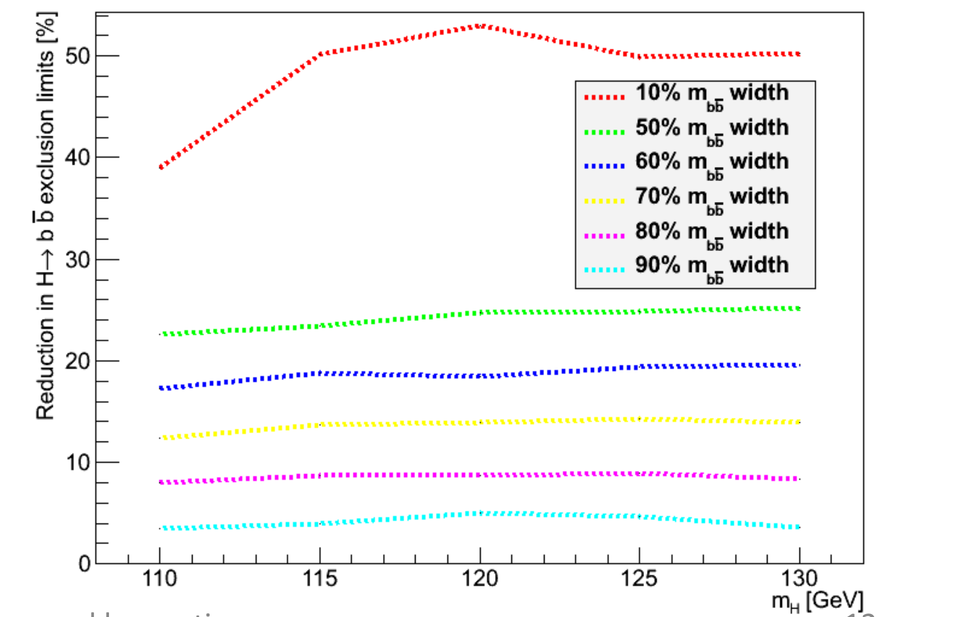


Backup

- 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)







MC requests

Inclusive and boosted H->bb samples for MC11b:

- Herwig++ in Powheg
- Mass points: M_H = 110, 115, 120, 125, 130, 135, 140, 145, 150 GeV
- WH->lvbb, ZH->llbb, ZH->vvbb
- Both boosted and inclusive for each mass

- Approved for production – still in waiting list for MC11b production (delays in MC11a)

- Other samples:
  - Wbb, Zbb
  - ZH, WZ, WW -> lljj and llbb final states
  - Gluon-fusion H->bb

- See Junichi's page: https://twiki.cern.ch/twiki/bin/view/AtlasProtected/HSG5Higgs2bbFinalState#H_bb_MC_samples

Priority-1 WH signal samples for MC11b

- New signal samples:
  - 128061 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 110 30k
  - 128062 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 115 30k
  - 128063 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 120 30k
  - 128064 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 125 30k
  - 128065 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 130 30k
  - 128066 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 135 30k
  - 128067 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 140 30k
  - 128068 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 145 30k
  - 128069 WH, W->lnu, H->bb (l=e,mu,tau) Herwig++/PowHeg 150 30k

- WH->lnubb with 1-lepton filter (e/mu, pT>15GeV) – Already in MC11a (mc11_001)
  - 116590 WH, W->lnu, H->bb (l=e,mu,tau) with 1lep(e/mu 15GeV) Pythia 115 100k
  - 116591 WH, W->lnu, H->bb (l=e,mu,tau) with 1lep(e/mu 15GeV) Pythia 120 100k
  - 116592 WH, W->lnu, H->bb (l=e,mu,tau) with 1lep(e/mu 15GeV) Pythia 130 100k
  - 116127 WH, W->inc, H->bb Herwig 120 30k - inclusive W decay

Priority 2 – Boosted WH samples

- New samples requested for MC11b:
  - 128030 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV with 1lep EF Pythia8 115 10k
  - 128031 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 110 10k
  - 128032 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 115 10k
  - 128033 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 120 10k
  - 128034 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 125 10k
  - 128035 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 130 10k
  - 128036 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 135 10k
  - 128037 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 140 10k
  - 128038 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 145 10k
  - 128039 WH, W->lnu, H->bb (l=e,mu,tau) pT(W)>100GeV Herwig++/PowHeg 150 10k
- Existing sample for cross check:
  - 109140 WH, W->incl, H->bb, Pt(H/W)>150/100GeV, 1e/mu filter Herwig 120 20k

Priority 1 – ZH->llbb signal samples

- New signal samples:
  - 128071 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 110 30k
  - 128072 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 115 30k
  - 128073 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 120 30k
  - 128074 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 125 30k
  - 128075 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 130 30k
  - 128076 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 135 30k
  - 128077 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 140 30k
  - 128078 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 145 30k
  - 128079 ZH, Z->ll, H->bb (l=e,mu,tau) Herwig++/PowHeg 150 30k

- Existing samples in MC10:
  - 116312 ZH, Z->ll, H->bb (l=e,mu,tau) Pythia 115 30k
  - 116313 ZH, Z->ll, H->bb (l=e,mu,tau) Pythia 125 30k
  - 116314 ZH, Z->ll, H->bb (l=e,mu,tau) Pythia 130 30k
  - 116128 ZH, Z->inclusive, H->bb Herwig 120 30k

Priority 2 – Boosted ZH->llbb samples

- New samples requested for MC11b:
  - 128040 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV with 1lep EF Pythia8 115 10k
  - 128041 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 110 10k
  - 128042 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 115 10k
  - 128043 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 120 10k
  - 128044 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 125 10k
  - 128045 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 130 10k
  - 128046 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 135 10k
  - 128047 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 140 10k
  - 128048 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 145 10k
  - 128049 ZH, Z->ll, H->bb (l=e,mu,tau) pT(Z)>100GeV Herwig++/PowHeg 150 10k

Priority 1 – ZH->ννbb signal samples

- New signal samples:
  - 128081 ZH, Z->nunu, H->bb Herwig++/PowHeg 110 10k
  - 128082 ZH, Z->nunu, H->bb Herwig++/PowHeg 115 10k
  - 128083 ZH, Z->nunu, H->bb Herwig++/PowHeg 120 10k
  - 128084 ZH, Z->nunu, H->bb Herwig++/PowHeg 125 10k
  - 128085 ZH, Z->nunu, H->bb Herwig++/PowHeg 130 10k
  - 128086 ZH, Z->nunu, H->bb Herwig++/PowHeg 135 10k
  - 128087 ZH, Z->nunu, H->bb Herwig++/PowHeg 140 10k
  - 128088 ZH, Z->nunu, H->bb Herwig++/PowHeg 145 10k
  - 128089 ZH, Z->nunu, H->bb Herwig++/PowHeg 150 10k
- Existing samples in MC10:
  - 109351 ZH, Z->nunu, H->bb Pythia 120 30k - Already in MC11a

Priority 2 – Boosted ZH->ννbb samples

- New samples requested for MC11b:
  - 128050 ZH, Z->nunu, H->bb pT(Z)>100GeV with 1lep EF Pythia8 115 10k
  - 128051 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 110 10k
  - 128052 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 115 10k
  - 128053 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 120 10k
  - 128054 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 125 10k
  - 128055 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 130 10k
  - 128056 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 135 10k
  - 128057 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 140 10k
  - 128058 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 145 10k
  - 128059 ZH, Z->nunu, H->bb pT(Z)>100GeV Herwig++/PowHeg 150 10k

Priority 2 – VBF samples

- Gluon-fusion H->bb sample:
  - Existing sample:
    - 128380 ggF H->bb Pythia6.4 115GeV 10k
  - Request: extend this sample to 50k
  - We expect 65k in 5fb^{-1}, but could do the rest in AFII for example

- VBF H->bb: extend this sample to 30k:
  - 116090 VBF H->bb Herwig 120 20k
  - Already existing samples in MC10:
    - 116306 VBF H->bb Herwig 115 30k
    - 116090 VBF H->bb Herwig 120 20k
    - 116307 VBF H->bb Herwig 125 30k
    - 116308 VBF H->bb Herwig 130 30k
    - 116091 VBF H->bb with mJJ>400GeV Herwig 120 40k

Priority 2 – ttH samples

- Existing samples in MC10
  - 128020 ttH -> bl+(e,mu)nbqq bbbar (positive lep) Pythia6.4 110 30k
  - 128021 ttH -> bl+(e,mu)nbqq bbbar (negative lep) Pythia6.4 110 30k
  - 116300 ttH -> bl+(e,mu)nbqq bbbar (positive lep) Pythia6.4 115 30k
  - 116303 ttH -> bl+(e,mu)nbqq bbbar (negative lep) Pythia6.4 115 30k
  - 109840 ttH -> bl+(e,mu)nbqq bbbar (positive lep) Pythia6.4 120 30k
  - 109841 ttH -> bl+(e,mu)nbqq bbbar (negative lep) Pythia6.4 120 30k
  - 116301 ttH -> bl+(e,mu)nbqq bbbar (positive lep) Pythia6.4 125 30k
  - 116304 ttH -> bl+(e,mu)nbqq bbbar (negative lep) Pythia6.4 125 30k
  - 116302 ttH -> bl+(e,mu)nbqq bbbar (positive lep) Pythia6.4 130 30k
  - 116305 ttH -> bl+(e,mu)nbqq bbbar (negative lep) Pythia6.4 130 30k
  - 128030 ttH -> bl+(e,mu)nbqq bbbar (positive lep) Pythia6.4 140 30k
  - 128031 ttH -> bl+(e,mu)nbqq bbbar (negative lep) Pythia6.4 140 30k

Background samples

- New:
- - ZZ->vvqq - would be good to have 100k generated with e.g. Sherpa - maybe already exists
- - WW->lnuqq - xsec is 46pb: would be good to have about 50k-100k with lepton filter - maybe already exists

- = top = total~7.5M
- 105200   ttbar (1-lepton) MC@NLO xsec=144.12pb 15M - would be good to have at least 7.5M (10 x #evt for 5fb-1)
- 108340 - 108345, 108346 - single top MC@NLO

- = ZZ = total=150k
- 109294   ZZ->2l2q   Pythia 0.841 pb   60k - already in MC11a

- 107108 ZZincllNp0 Alpgen 40k - already in MC11a
- 107109 ZZincllNp1 Alpgen 20k - already in MC11a
- 107110 ZZincllNp2 Alpgen 20k - already in MC11a
- 107111 ZZincllNp3 Alpgen 10k - already in MC11a

- = WZ = total=225k
- 105942   W+Z->qqll   MC@NLO   11.147pb*BR   25k - already in MC11a - would be good to extend this to 100k
- 105972   W-Z->qqll   MC@NLO   6.0394pb*BR   100k- already in MC11a
- 105940   W+Z->lnuqq MC@NLO   11.23 pb*BR 50k - already in MC11a - would be good to extend this to 100k
- 105970   W-Z->lnuqq   MC@NLO   6.085 pb*BR   50k - already in MC11a

= Wbb = total=920k

- These have only about 2x #evts for 5fb-1 - would be nice to increase
- 107280 WbbFullNp0_pt20 Alpgen 48 pb 475k - in production for MC11a
- 107281 WbbFullNp1_pt20 Alpgen 35 pb 200k - in production for MC11a
- 107282 WbbFullNp2_pt20 Alpgen 17 pb 175k - in production for MC11a
- 107283 WbbFullNp3_pt20 Alpgen 7.6pb 70k - in production for MC11a

AtlfastII could be used to extend these samples to:

- MC11.107280.AlpgenJimmyWbbFullNp0_pt20.py 3,500,000
- MC11.107281.AlpgenJimmyWbbFullNp1_pt20.py 2,500,000
- MC11.107282.AlpgenJimmyWbbFullNp2_pt20.py 1,500,000
- MC11.107283.AlpgenJimmyWbbFullNp3_pt20.py 500,00

= Wcc = total=650k

- 117284 WccFullNp0_pt20 Alpgen 128pb 250k - already in MC11a
- 117285 WccFullNp1_pt20 Alpgen 104pb 200k - already in MC11a
- 117286 WccFullNp2_pt20 Alpgen 52pb 100k - already in MC11a
- 117287 WccFullNp3_pt20 Alpgen 20pb 100k - already in MC11a

= Zbb = total=900k

- 109525 Z->ee+jets+b/c (enhanced) Sherpa 787pb 300k - in production for MC11a
- 109526 Z->mumu+jets+b/c (enhanced) Sherpa 787pb 300k - in production for MC11a
- 109527 Z->tautau+jets+b/c (enhanced) Sherpa 787pb 300k - in production for MC11a

= bb = total=9M

- 108405 bbmu15X PythiaB 4.5M - already in MC11a
- 108326 bbe15X PythiaB 4.5M - already in MC11a

= cc = total=3M

- 106059 ccmu15X PythiaB 1.5M - already in MC11a
- 108327 cce15X PythiaB 1.5M - already in MC11a

Cross sections

Channel	Cross section x BR (H->bb) at 7TeV	#evt in $5fb^{-1}$	Ref.
Gluon fusion H (m_H=115GeV)	18.7pb x 0.7 = 13.09	65.4k	LHC Higgs Xsec YR1
VBF (m_H=115GeV)	1312fb x 0.7 = 918fb	4.6k	LHC Higgs Xsec YR1
WH (m_H=115GeV)	755fb x 0.7 = 528fb	2.6k	LHC Higgs Xsec YR1
ZH (m_H=115GeV)	411fb x 0.7 = 288fb	1.4k	LHC Higgs Xsec YR1
ttH (semileptonic decay, m_H=115GeV)	39fb	195	Junichi's page
ttH (m_H=115GeV)	115fb x 0.7 = 80.5fb	402	LHC Higgs Xsec YR1
WW	46pb	230k	1109.2576v2 [hep-ex]
WZ	47.8pb (14TeV)	239k	CERN-OPEN-2008-020
ZZ	14.8pb (14TeV)	74k	CERN-OPEN-2008-020