H->bb Weekly Meeting

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HSG5 H->bb weekly meeting, 30 August 2011

Comparison with CMS Note

CDS record: http://cdsweb.cern.ch/record/1376636?ln=en

- Subjective impression:
  - Looks as clever as our own analysis but better optimized
- Some different strategic choices:
  - Included ZH->vvbb – best significance channel (S/√(S+B) = 0.25 @ m_H=115GeV)
  - B-jet selection:
    - 1 tight b-jet & 1 loose b-jet
    - Used sum of b-tag weights to select H->bb jet pair (Σp_T^{jet} for WH)
  - Selected a more boosted topology (but no jet substructure analysis):
    - Cut on vector boson and Higgs p_T allows cut on $\Delta\phi$(V,H)
  - Used m(H)-dependent m(bb) cuts
  - Used BDT: 10-20% improvement in each channel wrt cut-based
- According to note some significant differences in performance:
  - Better di-jet mass resolution
  - Better JES and b-tagging uncertainties

S/√(S+B) m_H=115GeV	WH->μνbb	WH->eνbb	ZH->μμbb	ZH->eebb
ATLAS	0.12		0.11	
CMS	0.21	0.23	0.12	0.13

Comparison between CMS' LP2011 results and our EPS2011 CONF note	
Channels	Included ZH->vvbb channel (best significance)
Multivariate	Boosted Decision Tree: ≈ 10 – 20% improvement in each channel
Monte Carlo	Hwg++/Powheg (NLO) for signal; Madgraph for some backgr
Trigger: some work spent optimizing this, esp. e triggers	Used particle flow for MET triggers & ≠ triggers for ≠ run periods WH: mu17, e22_2j30_j25_xe15 Z(ll)H: mu17, e17i_e8i Z(vv)H: j20 OR xe150
Missing energy	Particle-flow based MET and MET significance
Jets	Particle-flow jets: p_T > 30 GeV (WH), 20 GeV (llbb), 80/30 GeV (vvbb)
Pileup rejection	JVF-like algorithm plus calo-based algorithm
Leptons	p_T^{μ} > 20GeV, p_T^{e}>20(ZH)/30(WH)
B-tagging	Similar to IP3D+SV1; 1 tight (ε=50%) b-jet & 1 loose (ε=72%) b-jet Used sum of b-tag weights to select H->bb jet pair (Σp_T^{jet} for WH)
Other cuts	Cut on Δϕ(V,H) in conjunction with p_T^{V} and p_T^{bb} (≈ 100-160 GeV) m(bb) window cuts: m_H ± 15 GeV
m(H) reconstruction	Efficiency of m_H window cut (m_H±15GeV) ≈75-80% If normal distr. => 1.2×σ(bb), i.e. σ(bb)≈13 GeV (20GeV for us)
Systematics	Similar except: JES (1%) & of b-tagging (10%) – (9% & 16% for us)

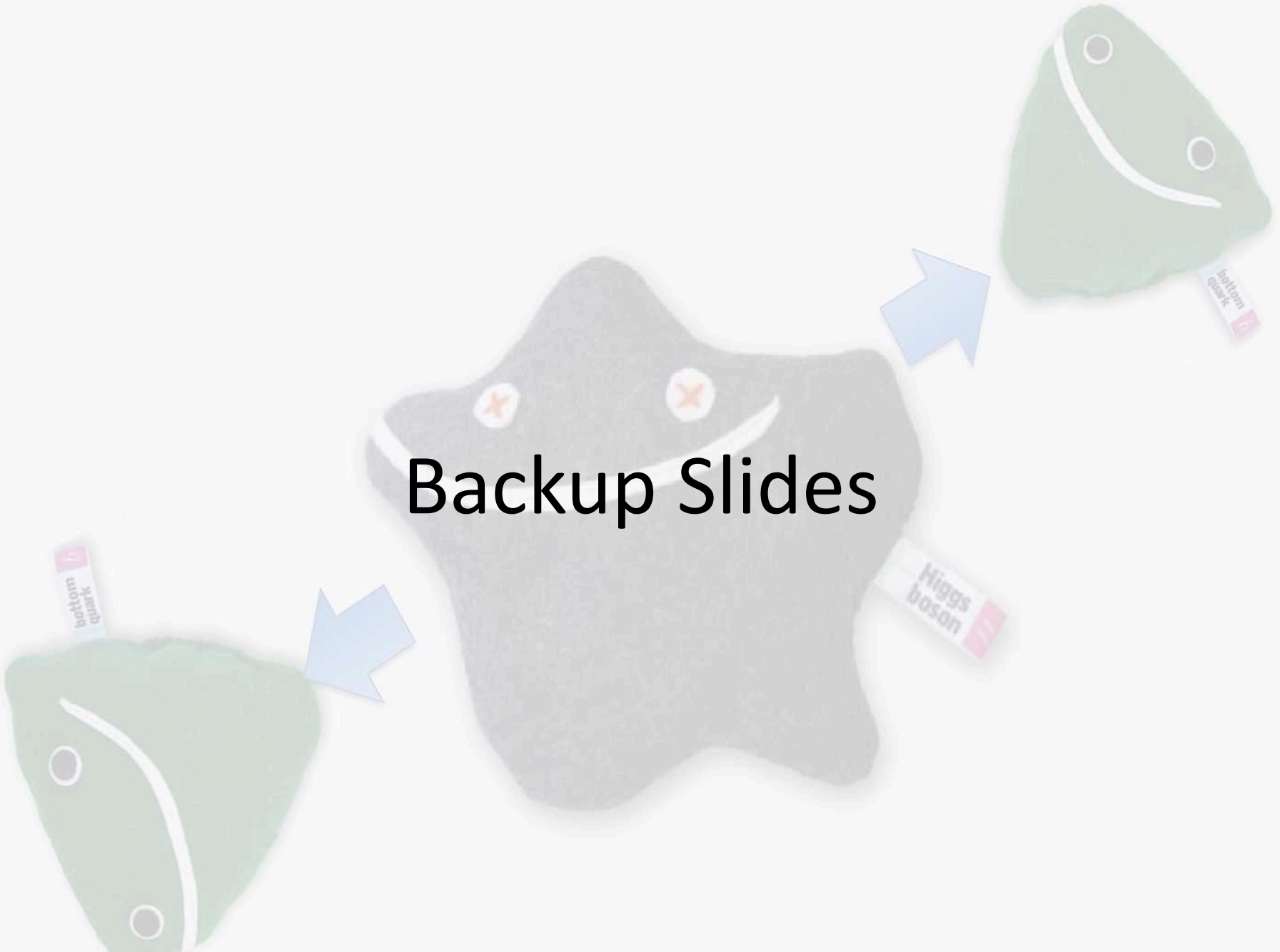
Monte Carlo samples

- MC10b – for analysis of rel.16 data before moving to rel.17
- Un-boosted analyses: done
  - WH->lnubb, and ZH->llbb samples (with l = e, mu, or tau, all tau decays allowed)
  - Generated with Herwig++ in Powheg (i.e. at NLO)
  - 30k events for each of the mass points: m(H) = 110, 115, 120, 125, 130, 135, 140, 145, 150 GeV
  - ZH->nunubb:
  - 10k events for each of the mass points: m(H) = 110, 115, 120, 125, 130, 135, 140, 145, 150 GeV,
  - Generated with Herwig++ in Powheg (i.e. at NLO)
  - Plus 10k events for ZH->nunubb with m(H)=115GeV generated with Pythia8
  - Total = 640k events
- Boosted analyses: done
  - WH->lnubb, ZH->llbb samples (with l = e, mu with a generator-level filter) and ZH->nunubb
  - Generated with Herwig++ in Powheg (i.e. at NLO)
  - Fltered on pT(H)>100GeV
  - 10k events for each of the mass points: m(H) = 110, 115, 120, 125, 130, 135, 140, 145, 150 GeV
  - Plus 10k events of each channel with m(H)=115GeV generated with Pythia8
  - Total = 300k events
- Essential backgrounds: UCL???
  - For un-boosted analyses: 1M events of Zbb and 1M of Wbb with Sherpa
  - For boosted analyses: 1M events of Zbb and 1M of Wbb with Sherpa with a cut on pT(V)+= 4M events
- Grand total: 4.94M events

Next Meetings

- Martin Flechl will take care of the next two meetings
- Next one will needs to be together with the H^+ meeting on Wednesday 7th September
- Following on on Tuesday 13th September as usual

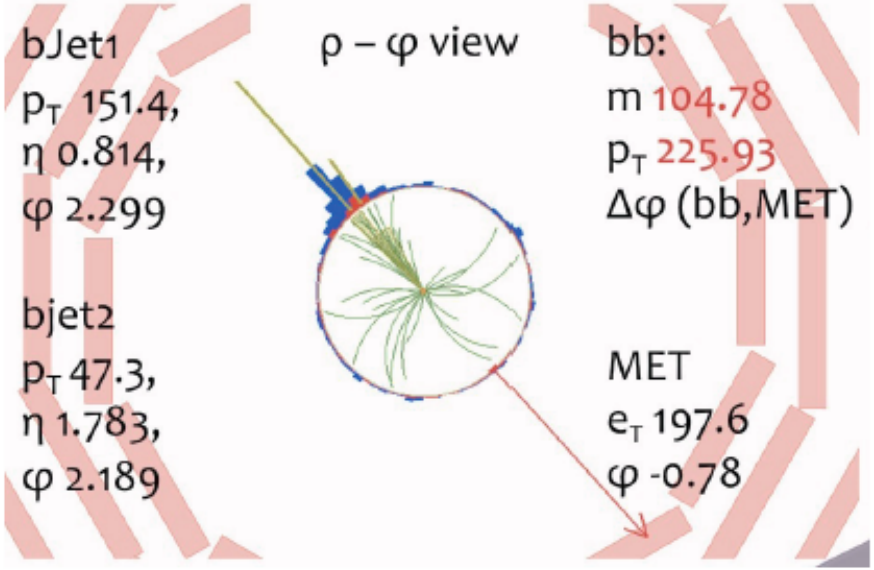
Backup Slides

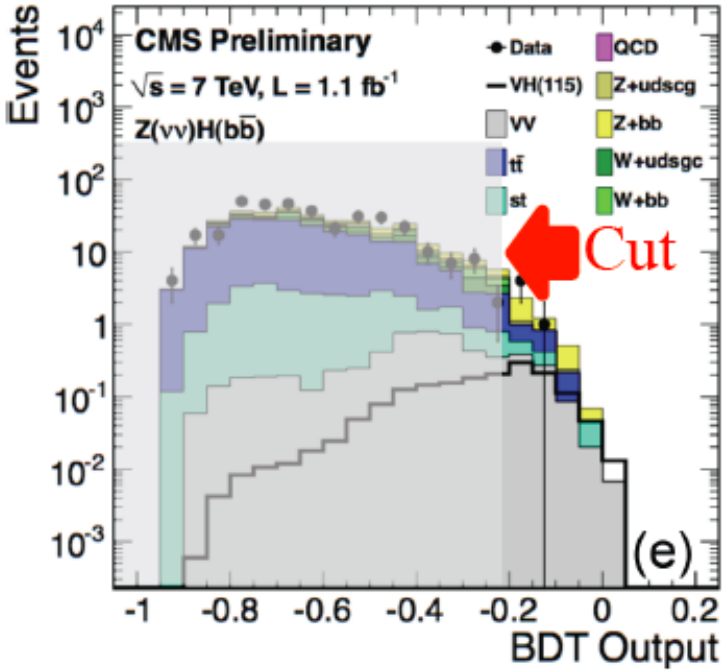


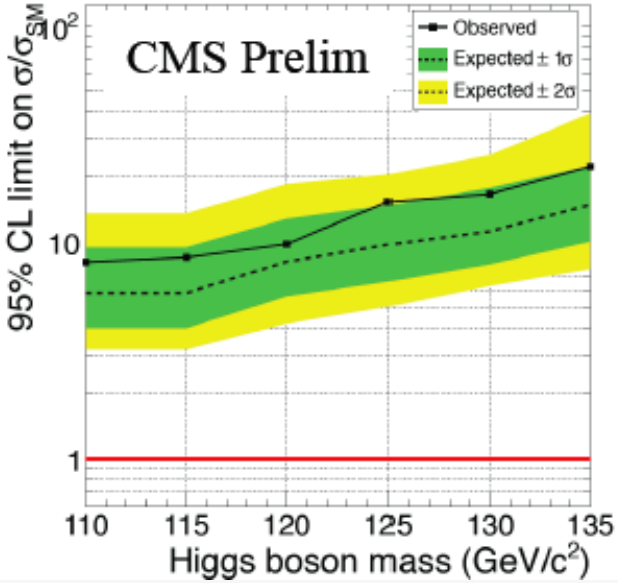
NEW: CMS H->bb at Lepton Photon

Low Mass Higgs Search : H→ b $\bar{b}$

- gg→ H→ bb and VBF are dominant production modes but overwhelmed by enormous QCD di-jet background
- Best option: qq→ VH; H → bb
  - Major backgrounds are V+jets, VV, ttbar
- Use
  - VH topology : $\Delta\Phi(V,H) > 3$
  - $P_T(V)$> 100-160 GeV (boosted W/Z)
  - Tight b-tagging & MET quality
  - Backgrounds estimated from control data







Vivek Sharma – LP2011

Trigger! Be worried! Be very worried!

- **Higher-threshold triggers** in use since period **K**
  - $3x10^{33}$ prescale set used since 4th August, run 186873
  - Several combined MET chains and and L1_MU10 unprescaled in last part of each fill
- Single-electron triggers will use isolation
  - Problem for fake electron background estimation
  - Nice page from Will Bell (top group) with list of planned studies: https://twiki.cern.ch/twiki/bin/view/AtlasProtected/FakeLeptonTriggers
- A new sample T was just produced for trigger studies
  - Using AtlasTrigMC 16.6.7.7.1 cache; AMI tag: r2597
  - Sample names start with "valid": valid1.*.recon.AOD.e598_s933_s946_r2597_tid…
  - Useful for looking at recent changes for the 3e33 menu (e.g. e22_medium, e22_medium1, etc)
  - Similar sample may be produced with 17.0.X.Y if there's enough popular demand
  - See: https://twiki.cern.ch/twiki/bin/viewauth/Atlas/TriggerSampleT

Disabled or prescaled from run 186873:
2b10_medium_4L1J10
2b10_medium_L1_2J10J50
2b10_medium_3L1J20
2e12_medium
2mu4_DiMu
3b15_loose_4L1J15
3j75_a4tc_EFFS
L1FJ75_NoAlg
e15_medium_e12_medium
e20_loose
e20_loose1
e20_looseTrk
e20_medium
e20_medium1
e20_medium2
e20_medium_SiTrk
e20_medium_TRT
e7_tight_e14_etcut_Jpsi
g40_loose_EFxe40_noMu
ht350_a4tc_EFFS_L2je255
j100_a4tc_EFFS_ht350
j75_2j30_a4tc_EFSF_ht350
j75_j30_a4tc_EFFS_anymct150
j75_j30_a4tc_EFFS_anymct175
mu15i_medium
tau100_medium
tau125_medium
tau16_loose tau16_loose_e15_medium
tau16_loose_mu15
tau16_medium_mu10 tau29_loose

Post-mortem of WH/ZH results

- M_{bb} resolution is extremely poor
  - Should try to get a peak, but this needs work on jet (and b-jet) energy scale
  - Try to think about this together with jet/ E_T^{miss} people
  - Could we improve other things in jet reco to improve m_{bb}?
  - In ZH->llbb could try to use ll vs bb p_T balance to do in-situ calibration?
- B-tagging systematic uncertainty dominates by far
  - 16% vs 7-9% for JES and ≈1-2% others
  - Should be possible to improve this, since the error is dominated by the statistics used in b-tagging studies
  - Would improve limits by up to 25-30%
  - Think about this with b-tagging people
- Limits: must get help from roostats experts to understand the difference between expected and observed
- WH cuts on exactly 2 jets
  - A lot of signal is lost there – can it be improved?
- WH backgrounds:
  - Top and W+jets background estimate using simultaneous template fit to m_{bb} sidebands (<80GeV and 140-250GeV)
  - Probably should try to also constrain jet energy scale from this fit
  - JES changes m_{bb} distribution and could affect normalization of backgrounds
  - In light of H->WW results, should move upper sideband to e.g. 160-250GeV – at m_H=150GeV, σ*BR already 1/10 of value at 115GeV, but H->WW and H->bb resolution is very broad
  - Can top background be reduced further?
- ZH background from Z+bb seems irreducible – can it be improved?

WH/ZH analysis plans

- We can still try to improve cut based analysis:
  - Get a m_{bb} peak, improve b-tagging systematics, constrain JES in WH, etc…
  - Reduce top background in WH:
    - Try using looser leptons or extending lepton id to forward region to veto tt->lvlvbb
    - Loosen jet η cut (at $|\eta|<2.5$ now) and maybe p_T cut to veto tt->lvjjbb/jjjjjbb
  - But… must keep pileup and JVF in mind

- Reduce Z+bb background in ZH? Would probably need a clever new variable like $\cos^{*}\theta$

- Then clearly we should include multivariate methods
  - Used intensively by Tevatron
  - e.g. use NN to target top background – may allow to relax 2-jet cut in WH
  - NN may also help in rejecting Z+bb background in ZH?
  - See if MV method can improve existing b-tagging

- Add more channels!
  - Can something be done with ZH->vvbb? Very good channel in Tevatron, but complex and mature analysis
    - Academia Sinica group plans to work on this But trigger is the crucial part
  - Boosted VH is clearly the next thing to push! WH->lvbb and ZH->llbb, but also ZH->vvbb
    - UCL and Edinburgh working on this – should be enough manpower now, but need to get results soon
  - ttH has been slowly building up in Glasgow – will push for this to happen together with Chris