Semi-Leptonic tth(h→bb)

CPPM,RAL,Glasgow,Genova,RHUL,UCL

ATLAS UK Physics Meeting
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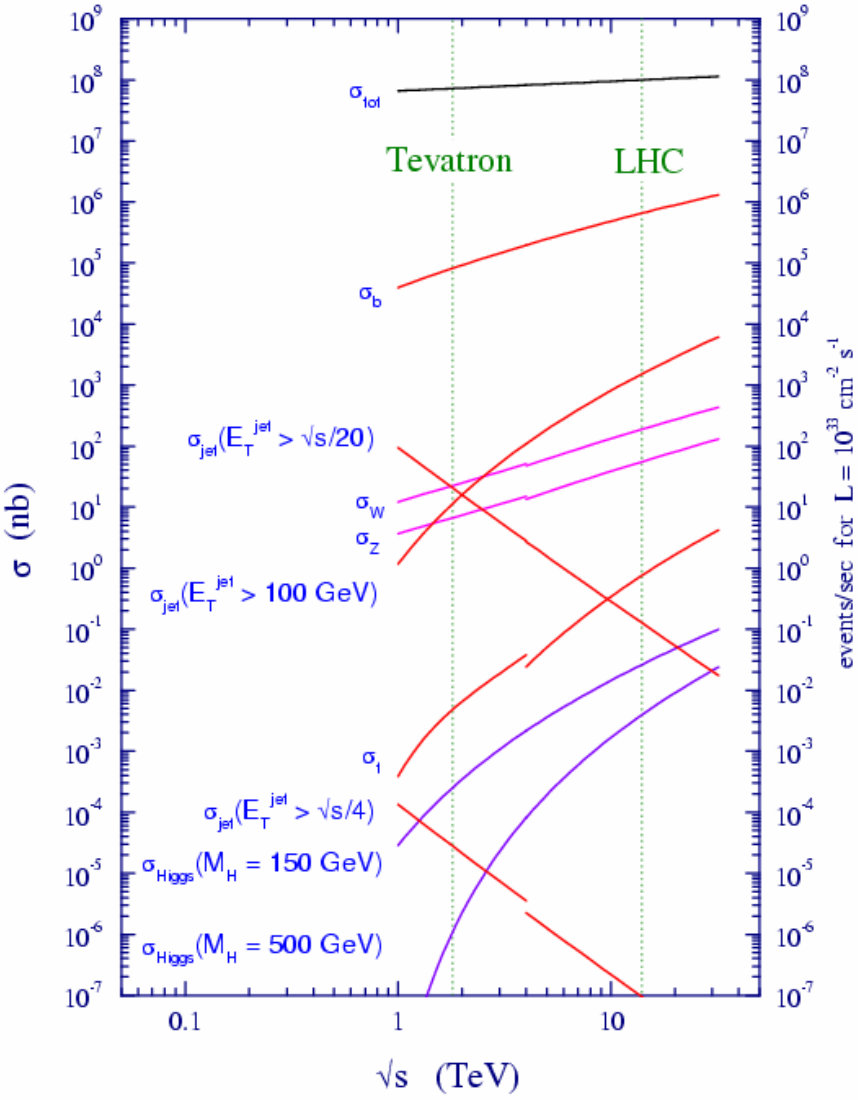
University of Glasgow

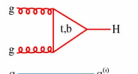
Running Conditions & Event Rates

- Luminosity scenarios:
  - For 2008: (initial running)
    - $L < 10^{33}$ cm^{-2} s^{-1}, $\int Ldt \sim 1$ fb^{-1}
  - For 2009: (low-luminosity phase)
    - $L = 1\text{-}2\ 10^{33}$ cm^{-2} s^{-1}, $\int Ldt < 10$ fb^{-1},
    - 30 fb^{-1} between 2008 and 2010/2011
  - Beyond: (high-luminosity phase)
    - $L \sim 10^{34}$ cm^{-2}s^{-1},
    - ~300 fb^{-1} by 2014/2015
- Pile-up:
  - ATLAS expects ~2 (low-lumi) or 20 (high-lumi) p-p minimum bias interactions per bunch crossing (25 ns)



LHC SM Higgs Production and Decay

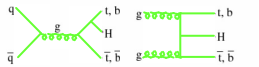
- Production processes , K-factors and cross-section uncertainties:



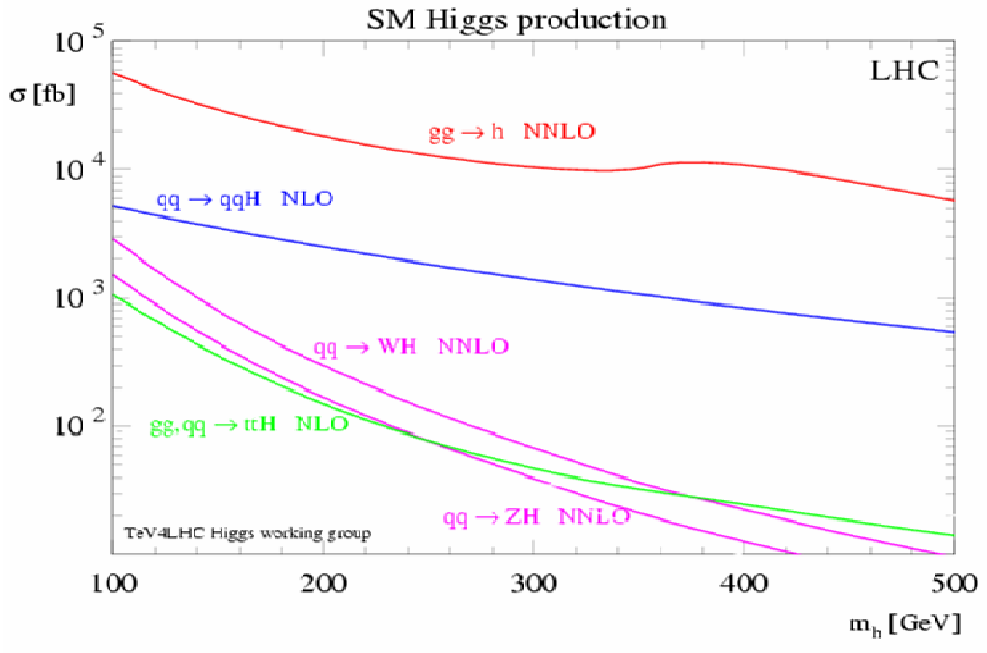
gluon fusion gg ⇒H — K~2.0, σ uncert ~10-20% NNLO

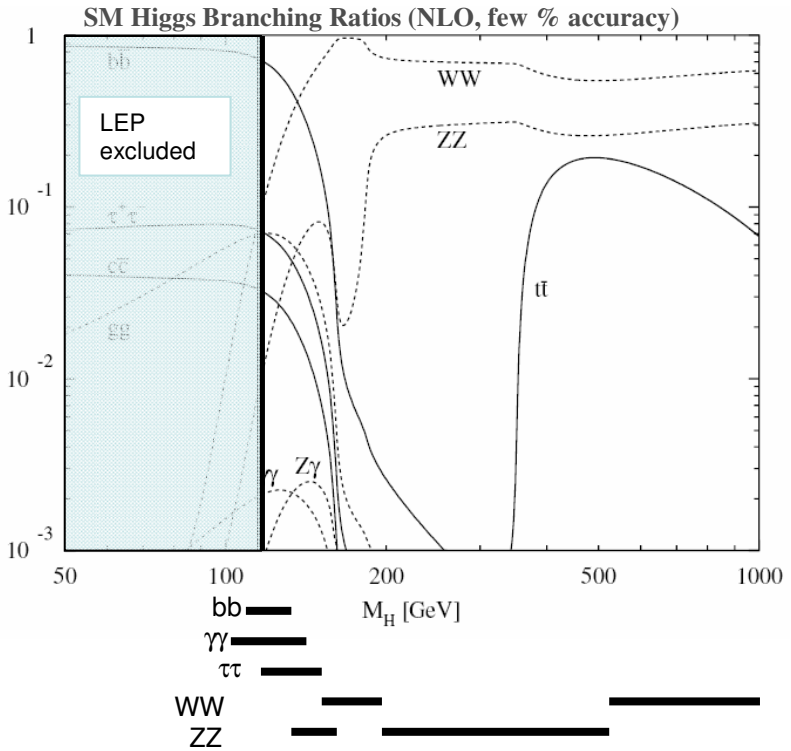
VBF qq' ⇒ q'q'H — K~1.2, σ uncert ~5% NLO

Z,W assoc. qq ⇒ HZ,W — K~1.4, σ uncert ~5% NNLO



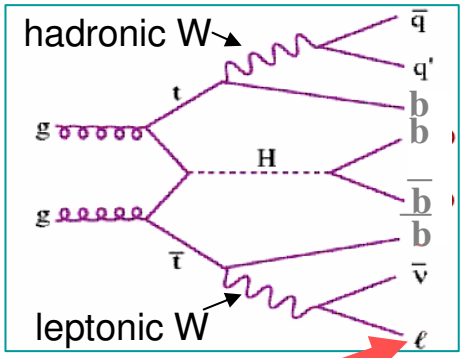
assoc. top gg,qq ⇒ Htt — K~1.1, σ uncert ~10% NLO





Semi-Leptonic final state

- Features:
  - Attractive due to large BR(H→bb) at M_H<130 GeV.
- Combinatoric background:
  - There are many ways to combine objects in the event
    → Large tails on mass reconstruction.



Semi-leptonic: trigger on high Pt isolated e,μ

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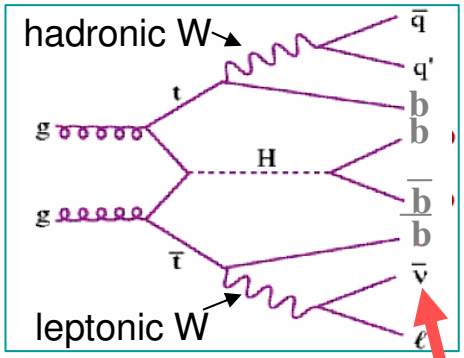

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Missing Et used to reconstruct neutrino

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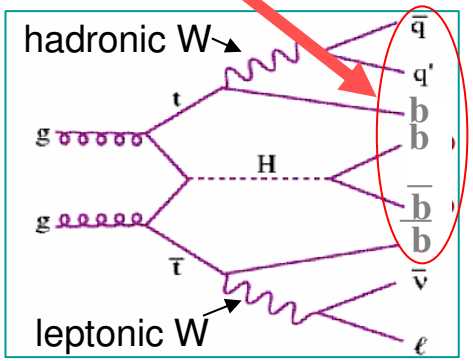

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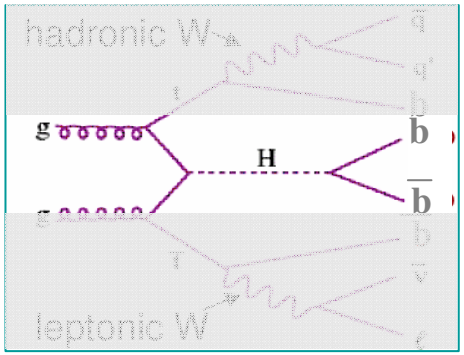
Require W,t's to be reconstructed



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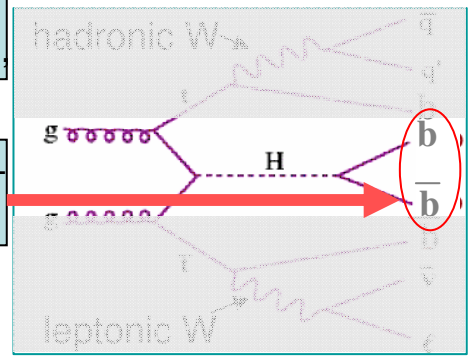

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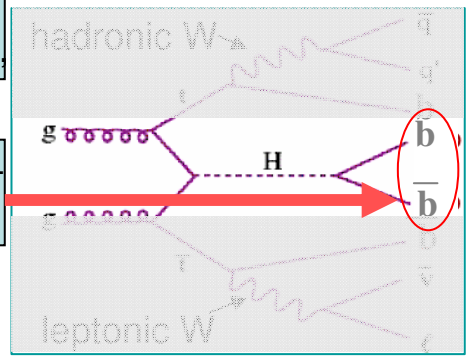
- Combinatoric background:
  - There are many ways to combine objects in the event
    → Large tails on mass reconstruction.
- Physics backgrounds:
  - Backgrounds must be determined from data, in MC σ(ttjj) dependent on scale choice.
  - ttjj: b-tagging optimised to reject light jets.
  - ttbb (QCD & EW): 2 extra b-jets are not from a Higgs (typically QCD, so gluon radiation).
    →Kinematic info can then be used to reject bg.

Select events with high jet multiplicity (≥6), at least 4 b-tagged jets.

Require W,t's to be reconstructed,

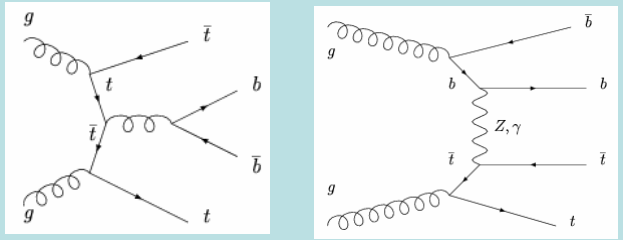
Use remaining b-jets for Higgs



Semi-leptonic: trigger on high Pt isolated e,μ

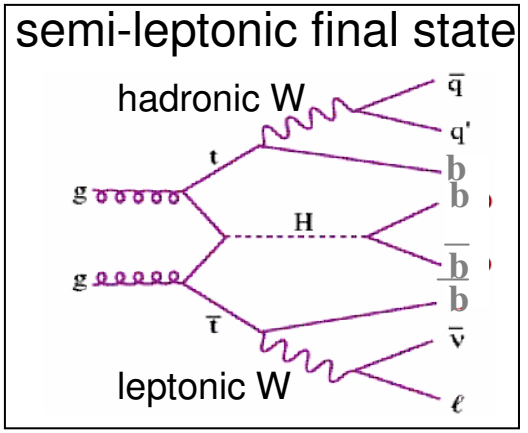
Missing Et used to reconstruct neutrino

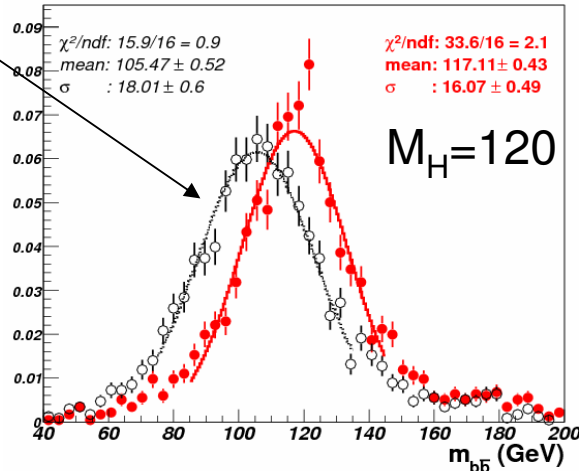
ttbb (QCD) ttbb (EW)



Preselection
(1 lepton, 6+jets, 4+bjets)

- **Electron Preselection (author ==1||3)**
  - Pt >25 GeV, |η| < 2.5
  - IsEM & 0xFF
  - Etcone20/$P_{T_{elec}}$ < 0.15
- **Muon Preselection (Staco HighPt: author==1)**
  - Pt >20 GeV, |η| < 2.5
  - .χ^2/n_{dof} <30
  - Etcone20/P_T< 0.3
  - $D0_{vtx}$ < 0.05 mm
- **Neutrino Reconstruction**
  - Solve $P_\nu z$ from 2nd order eqn. for W-mass
  - Use "Δ=0" if no real roots; (i.e. set –ve square root =0)
- **Soft Muons to add to jets (Staco Collection author==1||2)**
  - Not already passed muon preselection + inter-auth overlap removal
  - 4 < Pt < 100 GeV, |η| < 2.5
  - .χ^2/n_{dof} <30
  - Etcone20/P_T> 0.1 GeV
  - Add muon to jet when ΔR(μ,j)<0.4
- **Jet Preselection**
  - Pt > 20 GeV, |η| < 5
  - Elec. overlap removal (use elec): ΔR(e,j)<0.2 && $P_t$elec/$P_t$jet >0.75
  - Calibrate with Atlfast out-of-cone
- **B-tagging**
  - 4 of the preselected jets within |η| < 2.5,
  - SV1+IP3D >= 4.5, but Σbtag(h)_ll > 0, Σ4b_ll >8 used in constrained fit likelihood.





Analyses

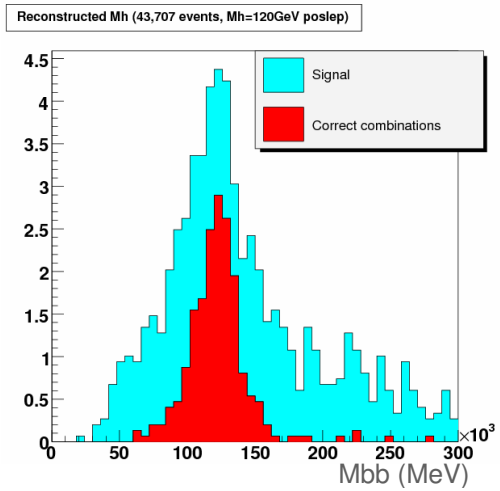
CPPM,RAL,Glasgow,UCL

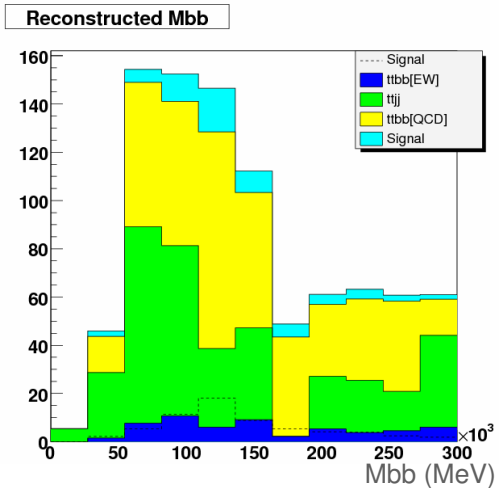
Currently use cut-based approach & two likelihood analyses:

- Cut-based: used as a baseline for likelihoods.
- Marseille analysis, based on combinatorial likelihood.
- CVS-based analysis using constrained mass fit with 3D likelihood.
- All use the same loose preselection.
- All normalised to 30 fb^{-1} and M_H=120GeV

Cut-based analysis

- Leptonic & Hadronic W reconstruction, mass-window cuts (±25 GeV) applied to remove e.g. QCD multijet background.
- t,tbar reconstruction to remove e.g. W+jets bg.
- Event combinatorics; choose comb. Minimising $\chi^2 = (m_{lnb}-m_t)^2 + (m_{jjb}-m_t)^2$.
- Produce M_{bb} from two remaining b-jets after t,tbar are reconstructed.



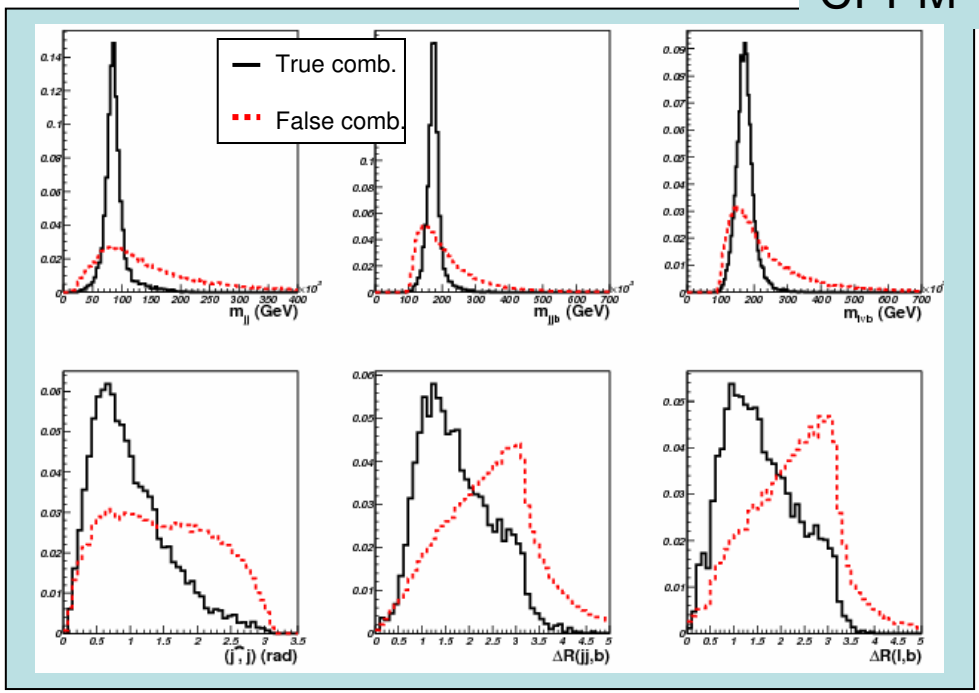


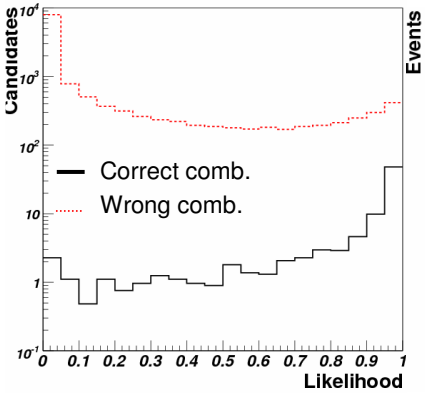
- Significance ~1.9
- Large tails on mass resolution

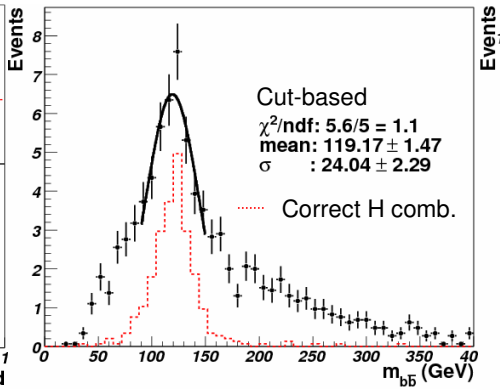
Combinatorial likelihood analysis

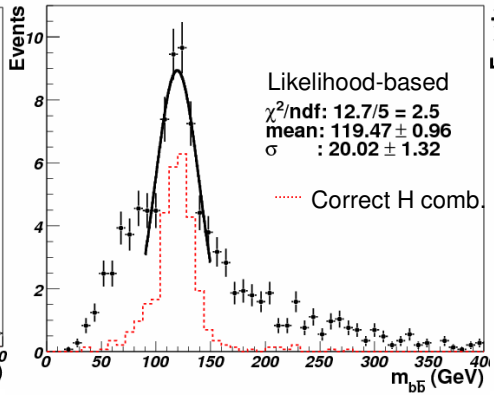
CPPM

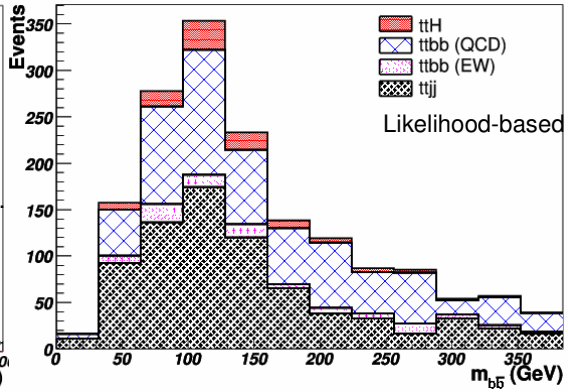
- Combinatorial lhd PDFs
  - done after preselection
- Combinatorial lhd improves significance over cuts-based for this working point.
- Also improves Higgs purity, resolution
- As before, suffers from lack of stats!
- S/√B=2.2 for cut on lhd=0.9 (Incl. mass window cut).











Constrained mass fit with 3-D lhd's

RAL

Pairing Likelihood:

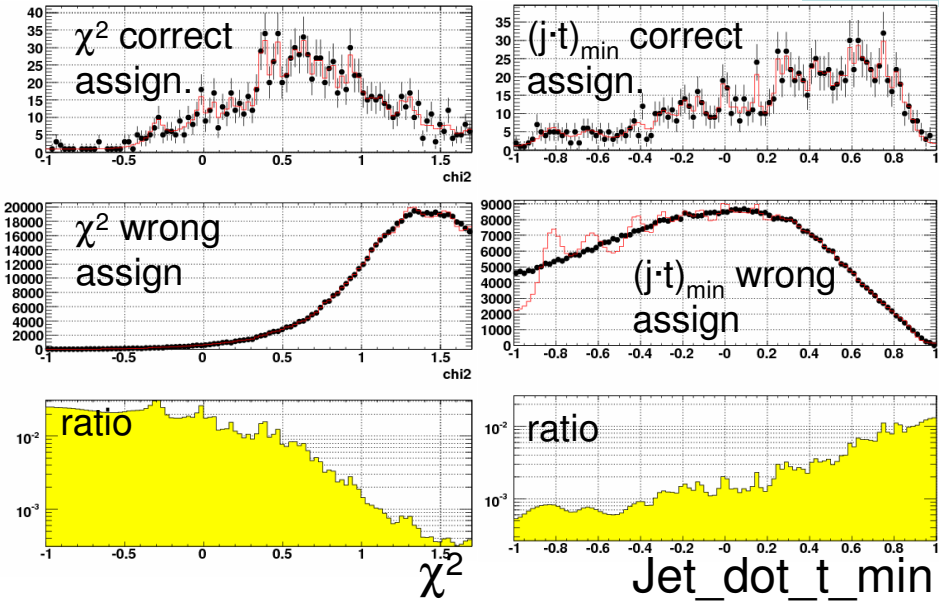
- Fit 7 parameters ($6E_j$, $P_z\nu$), form minimum χ^2
- Constraints:M_t, M_t, M_W, M_W, $6E_j^{meas}$
- Set of variables taken:

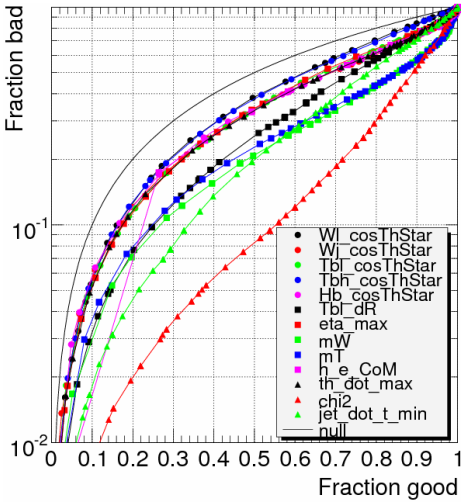
Full 3D lhd

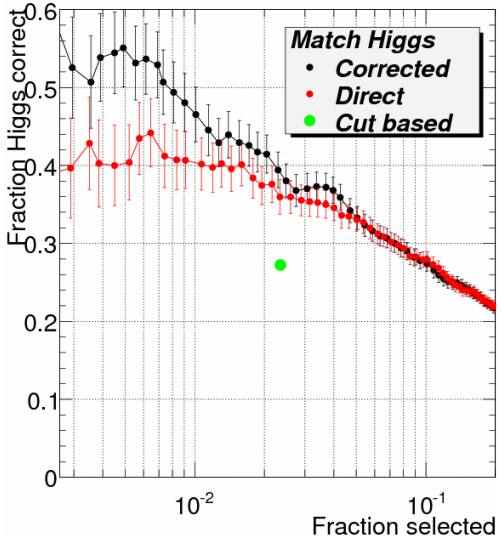
- χ^2
- jet_dot_t_min (Largest jet-top angle in CoM frame)

Treat as 1D

- Leptonic t-b cosθ*
- ΔR l-b (Leptonic top)
- Jet η_{max}
- Higgs-b cosθ*
- Raw hadronic M_t
- Jet Charge
- $\Sigma_{loglikelihood}$(4-btag)







Constrained mass fit with 3-D lhd's

RAL

Signal/Background:

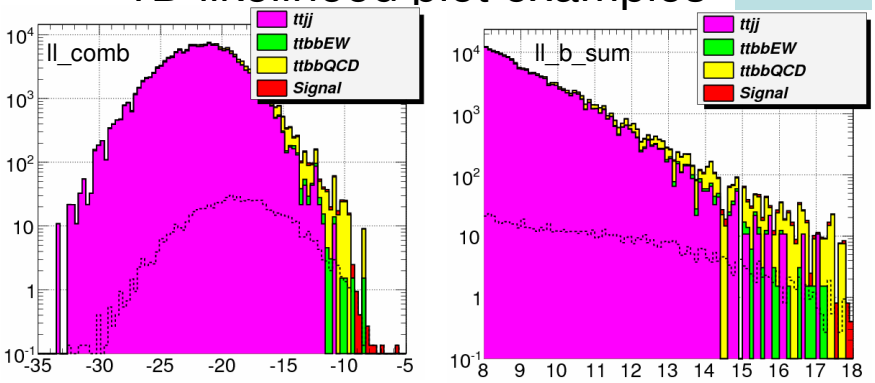
- Similar approach:
  - Major variables treated as full 3D
  - Minor ones added as if independent
- Set of variables taken:

Full 3D lhd
- ll from combinatorics
- ll_b_sum
- sum_btag_Higgs
- Δη H_top_min

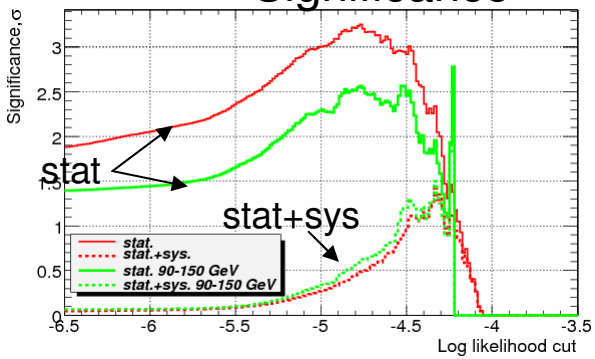
Full 3D lhd
- Max cos(tH) in CoM
- P_H in CoM
- Δη between Higgs jets

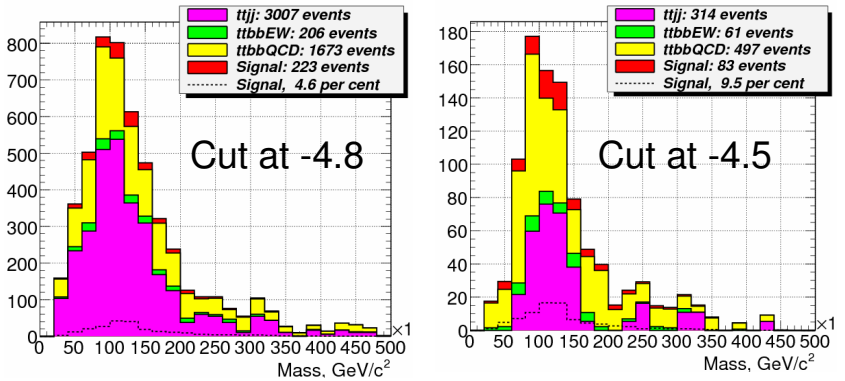
- Total Effect: peak in S/√B=3.2
  - (stat only – no systematics!)
  - (applying M_H window, S/√B=2.5)
- Completely arbitrary 10% sys err. on background, S/√B drops dramatically!

1D likelihood plot examples



Significance

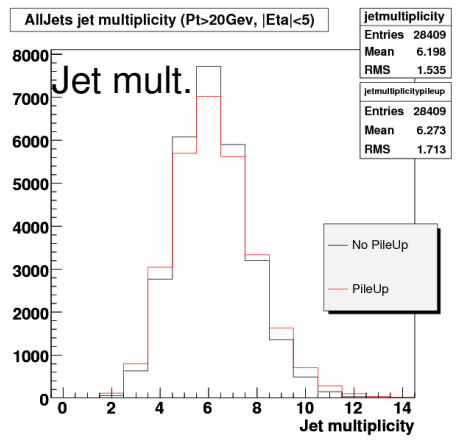


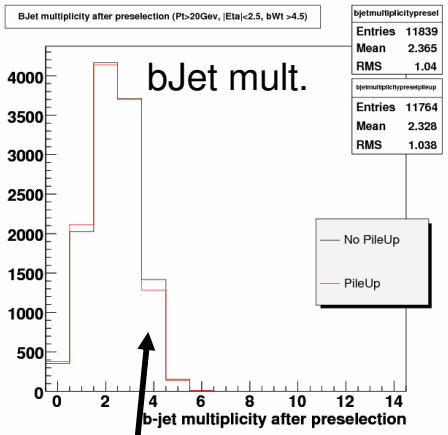


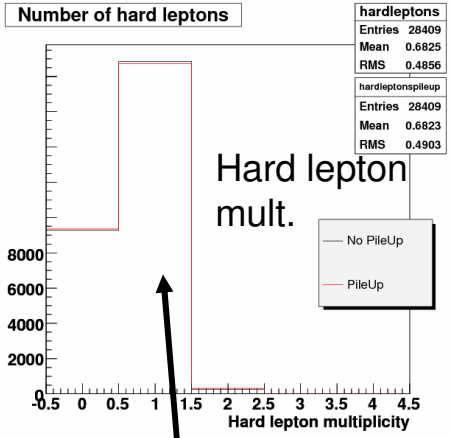
Pile-up

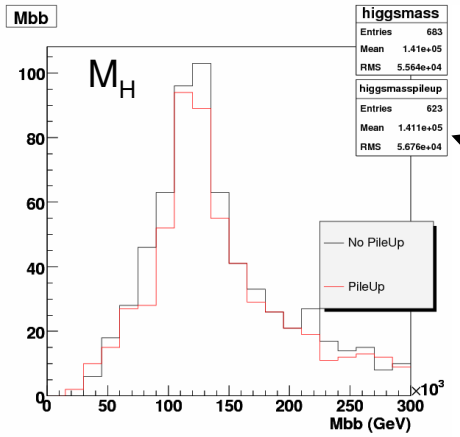
Glasgow

- Aim: study impact of pile-up on b-tagging performance, combinatorics, hard and soft leptons, mass resolutions.
- Background pile-up samples had a problem, >2Gb memory needed!
- First, look at signal samples only for low-lumi (10^{33}):









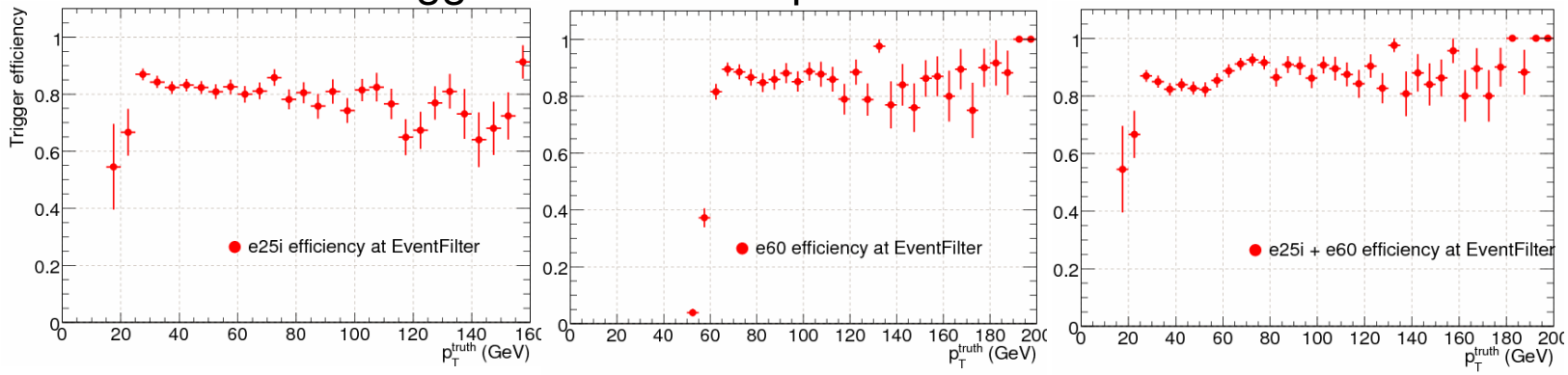
Effect on soft leptons likely to be larger

- ~9% loss of signal mainly due to reduction in events having >=4 b-jets.
- Backgrounds will be affected too.

Trigger

RHUL, UCL, Genova

- Analyses do not yet include trigger (to do!), but effects investigated for e25i, e60 & mu20i.
- Efficiencies calculated after preselection for e25i showed a high-Pt drop-off
- e60 was considered, and appeared to improve efficiency with a manageable expected rate increase.
- EtMiss and Jet triggers show some promise



[BERNIUS]

- Overall, efficiencies after preselection found to be:

Trigger level	ε(e25i or e60)	ε(e25i or mu20i)	ε(e25i or e60 or mu20i)
Level 1	98.7 ± 0.2%	88.3 ± 0.4%	92.4 ± 0.3%
Level 2	92.7 ± 0.4%	83.4 ± 0.4%	87.0 ± 0.4%
Eventfilter	86.0 ± 0.6%	79.7 ± 0.4%	82.7 ± 0.4%

Conclusions

- Cut-based & likelihood analyses:
  - Likelihood analyses improve significance for a particular working point.
  - Achieved as high as 3.2σ [RAL, M_h=120, 30fb^{-1}], *but* with no systematics included ☹
- Much work still to do:
  - Systematics
  - Trigger (esp. fully hadronic).
  - Fast Calo Sim sample for use in shape analysis.
  - Neural Net
  - Improving signal extraction