WW Scattering

Jon Butterworth, Adam Davison,
Erkcan Ozcan, Peter Sherwood - UCL
Sarah Allwood-Spiers - Glasgow

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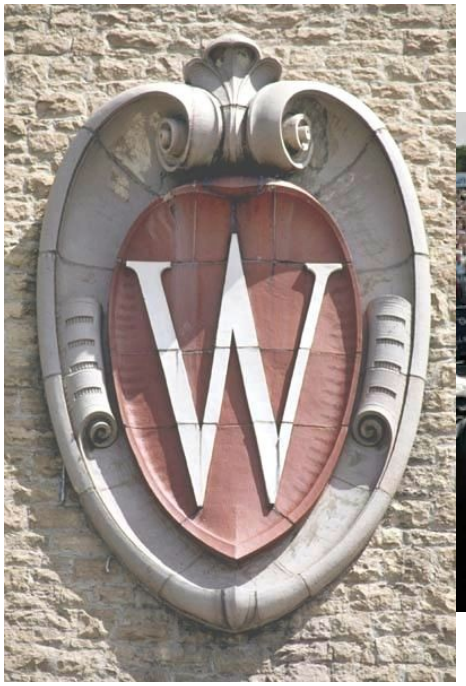
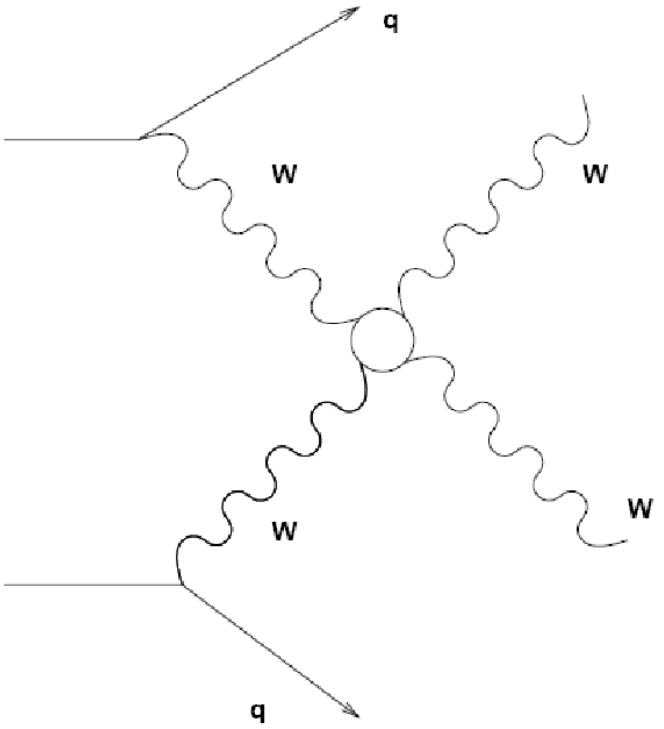


Vector Boson Scattering in 60 Seconds

- SM cross-section violates unitarity at ~1TeV
- Extra Higgs diagrams can save you
- Or something else
  - More extra particles
  - Weirder things...
  - Fairly model independent
  - Interesting even with light Higgs

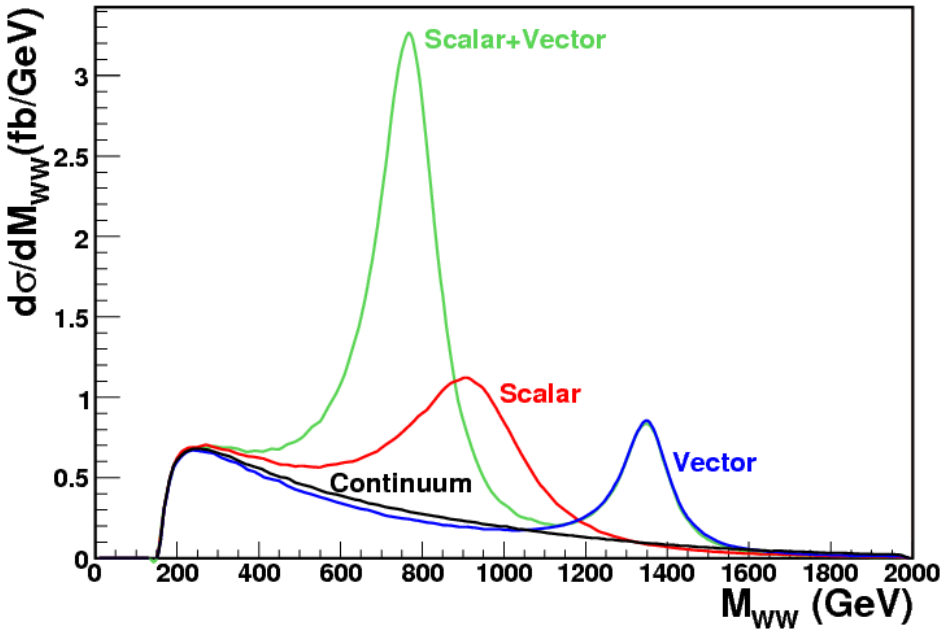


Experimental Signature

- Can study ZZ, WZ or WW
- UCL working on WW in semi-leptonic mode
  - 1 highly boosted hadronic W (1 or 2 central jets)
  - 1 leptonic W (1 isolated lepton and missing E_t)
  - 2 “tag” jets in the forward region
- Reach is new particles around 500GeV – 1TeV
- W+jets and $t\bar{t}$ are the main backgrounds

Can Study

- Cross-section (starting with upper limit)
- Invariant mass distribution for resonances
- Eventually even spin of resonance



Cuts in Brief

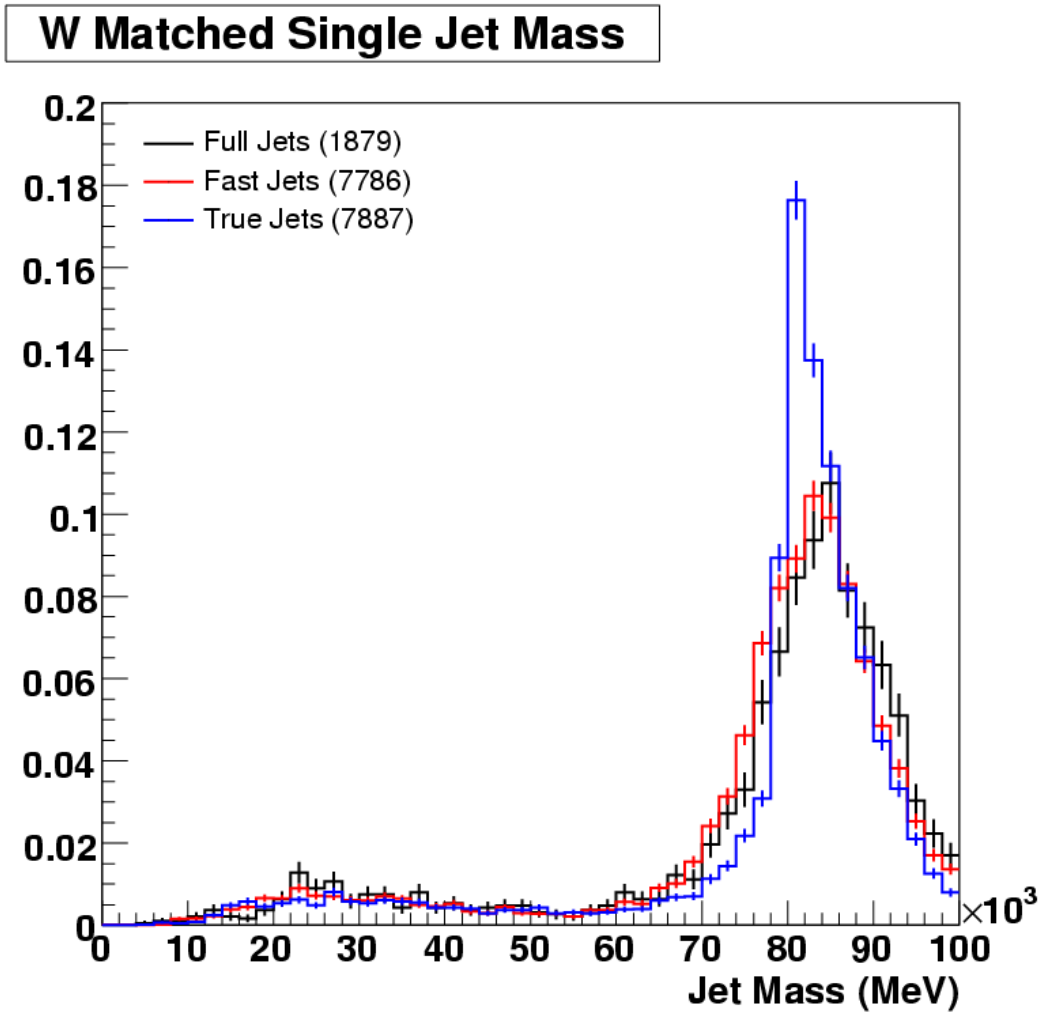
- Hadronic W Candidate (more later) $p_t > 200\text{GeV}$
- Leptonic W Candidate $p_t > 200\text{GeV}$
- Both central ($|\eta| < 2$)
- 1 forward and 1 backward tag jet
- Top-veto
- Central jet veto

Hadronic W Candidate

- Most challenging part of analysis
- W is often highly boosted, decays as 1 jet
- Can't use dijet mass window but still need to be able to identify W's vs much more prevalent QCD jets ...
- For lower pt, still fall back to “classic” 2 jet scenario

Single Jet Mass

- First weapon is to measure mass of the single jet
- Analogous to dijet mass
- Can apply window

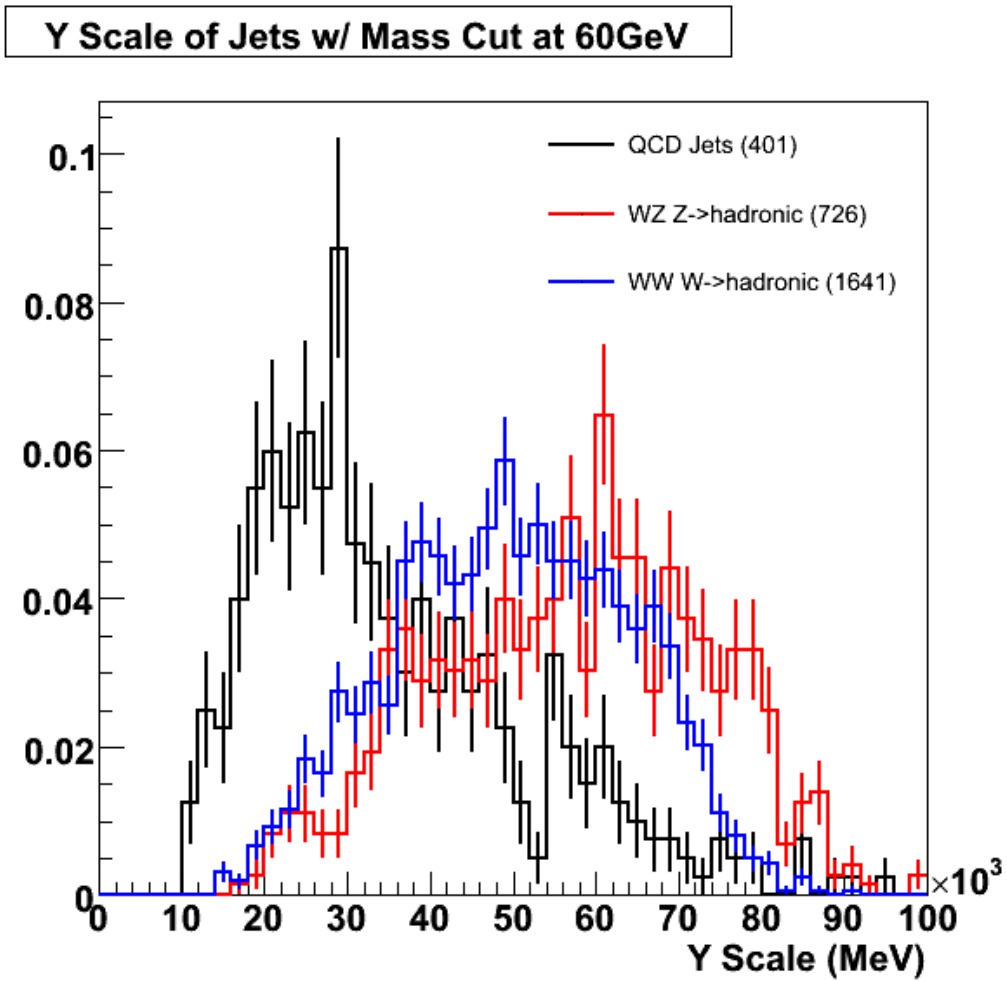


YSplitter

- Try to figure out if high mass is due to genuine hard splitting or just sum of many small masses
- Our jet of choice is Kt 0.6
- Take clustered Kt jet and go backwards
- Kt distance of final splitting gives y-scale
  - Scale at which jet can be resolved into two subjets

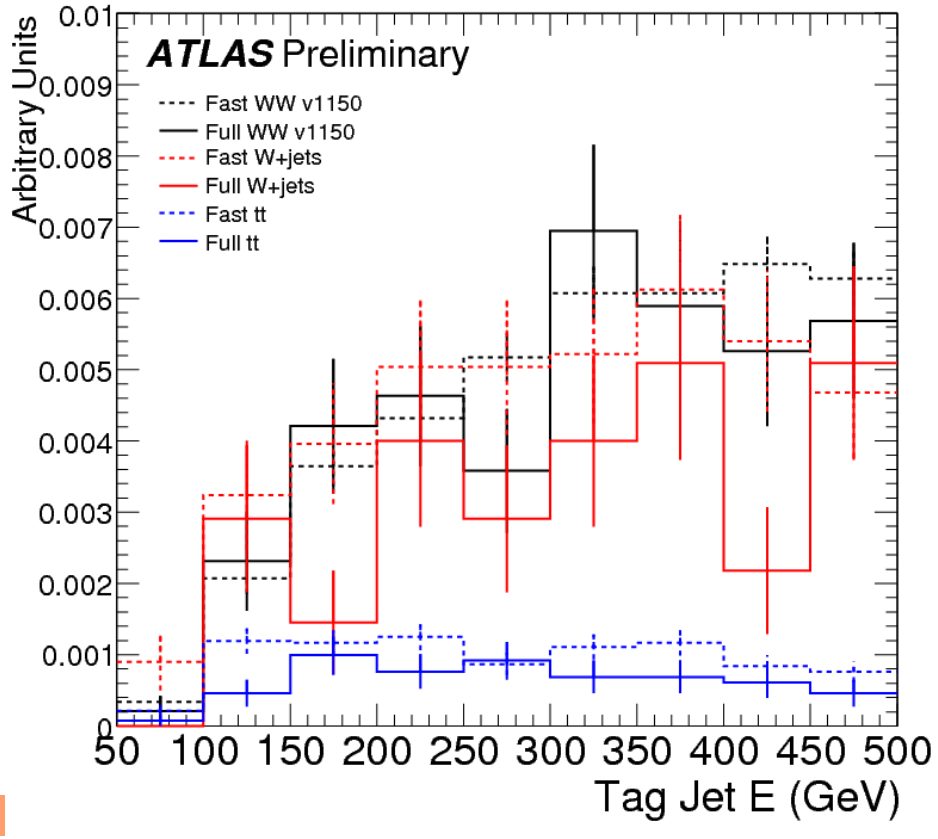
More YSplitter

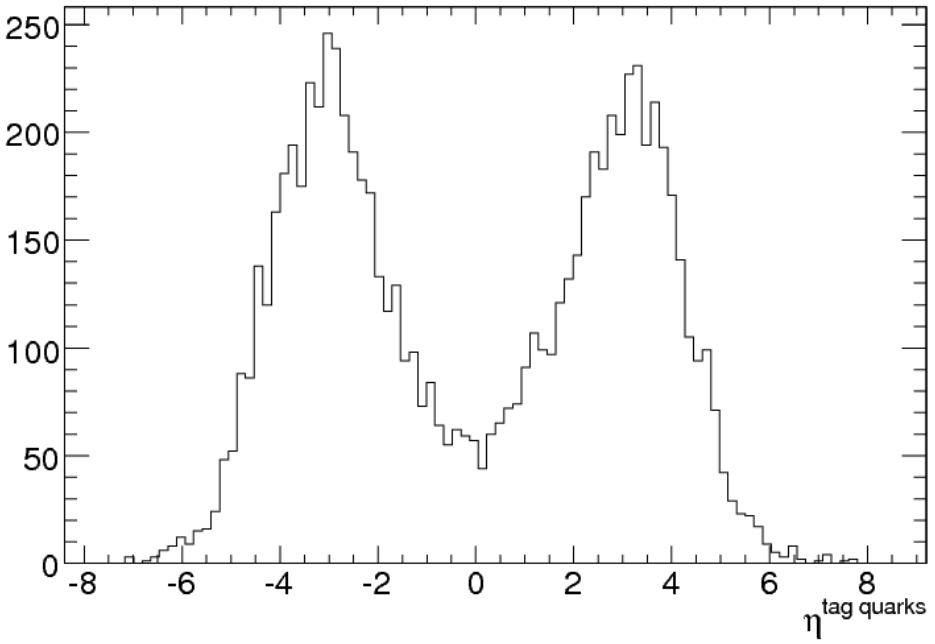
- Factor of 2-3 better than single jet mass alone in signal-to-background ratio



Forward Jets

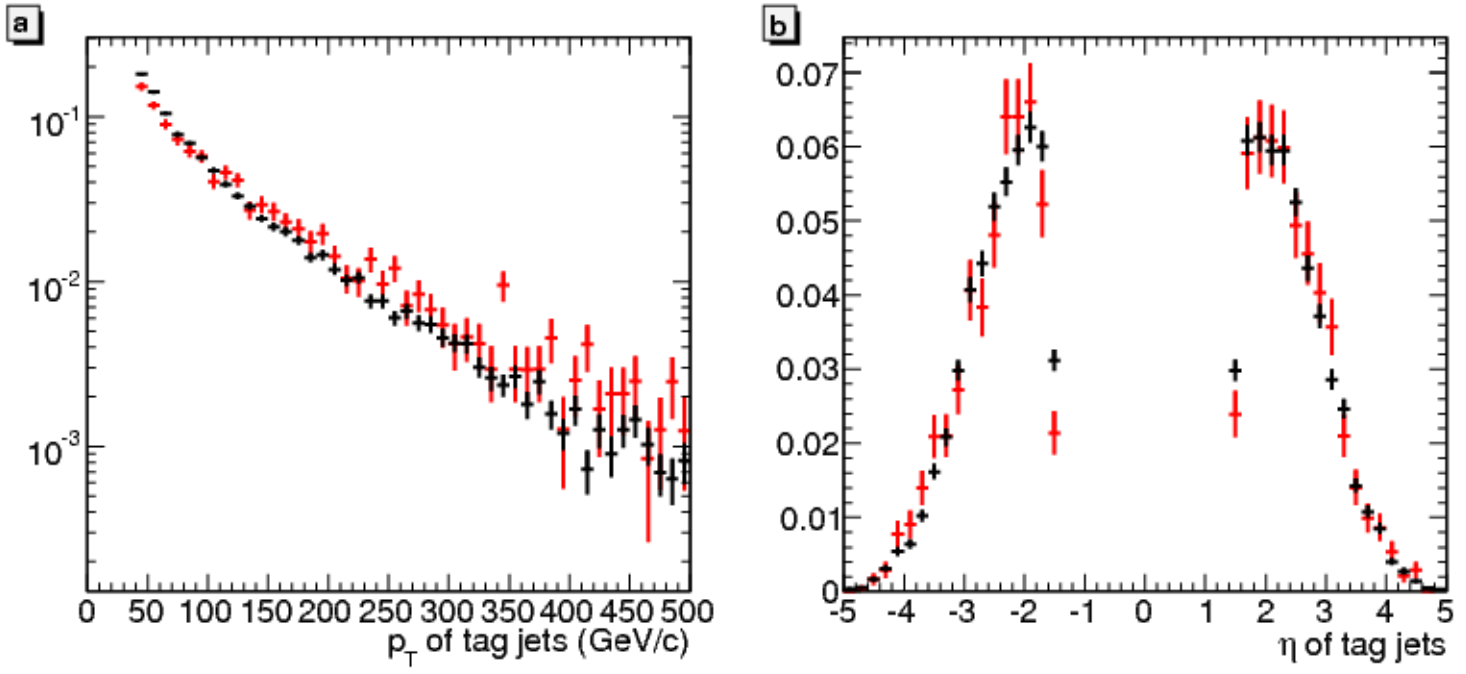
- letal > 2 and pt > 20GeV and $E_{highest}$ > 300GeV
- Still optimising, may go for delta eta in the end





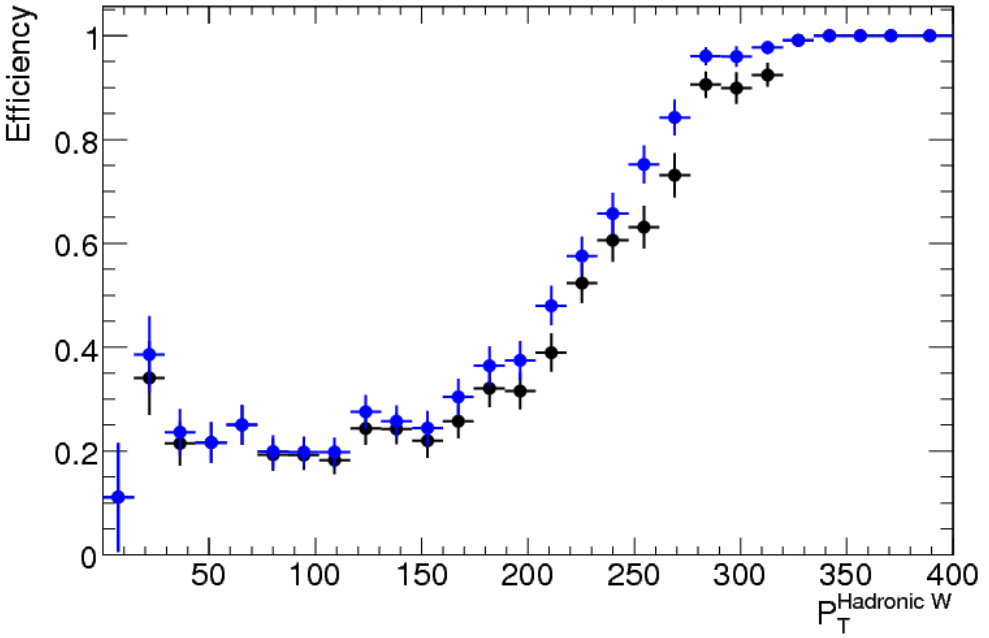
Monte Carlo Studies

- Various studies carried out
- For example, comparison of Alpgen and Madgraph for W+jets background



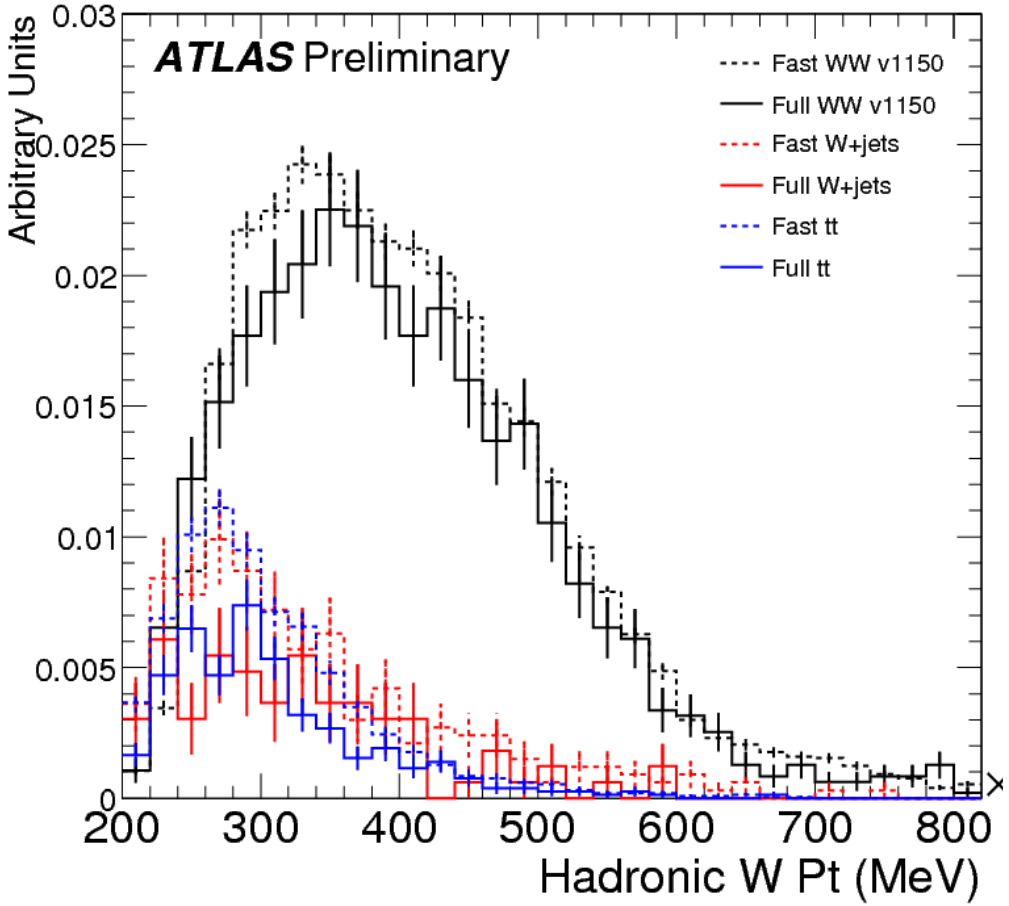
Trigger

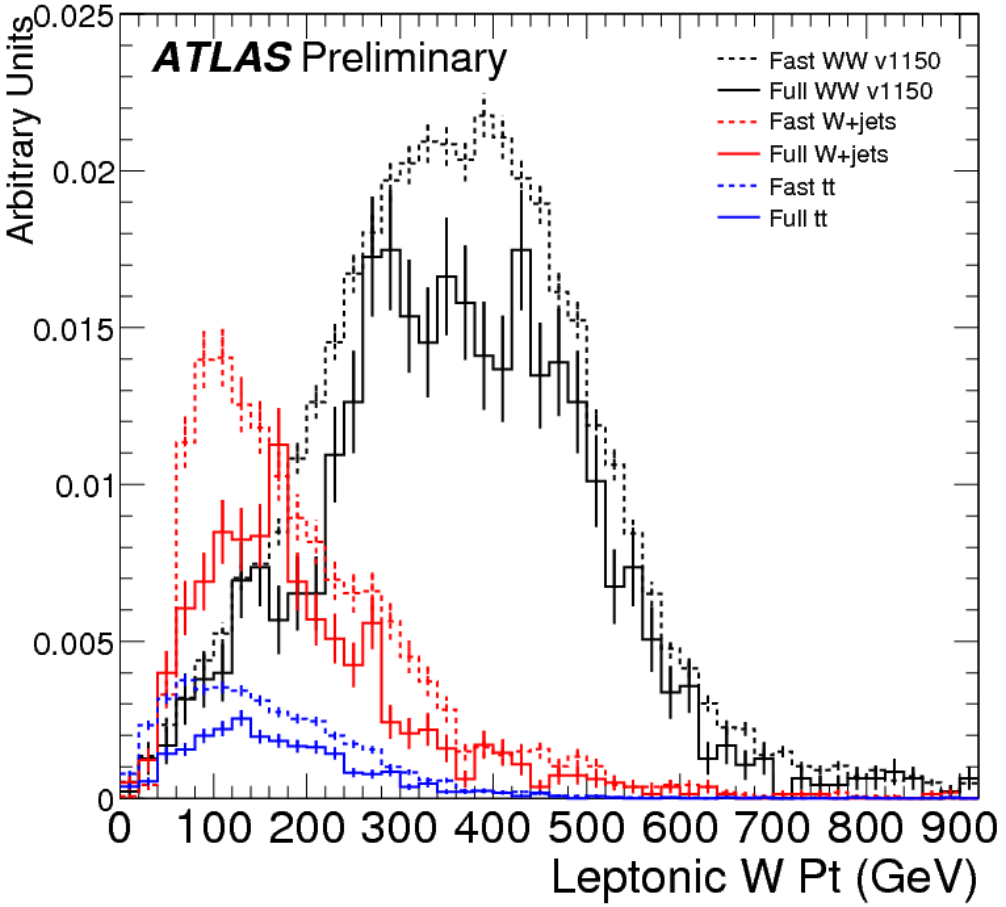
- Not particularly challenging for us
- Can take Lepton OR xEt OR Jet
- Well above thresholds for all but jets
- End up at >99%
- Black is jet160
- Blue jet160 || 2jet120



Working with Atlfast

- Only problem is lack of lepton efficiencies





Grid

- Same as everyone else
- Managed to do majority of our work on the grid
  - Used both GANGA and pathena

Sample of (Preliminary) Results

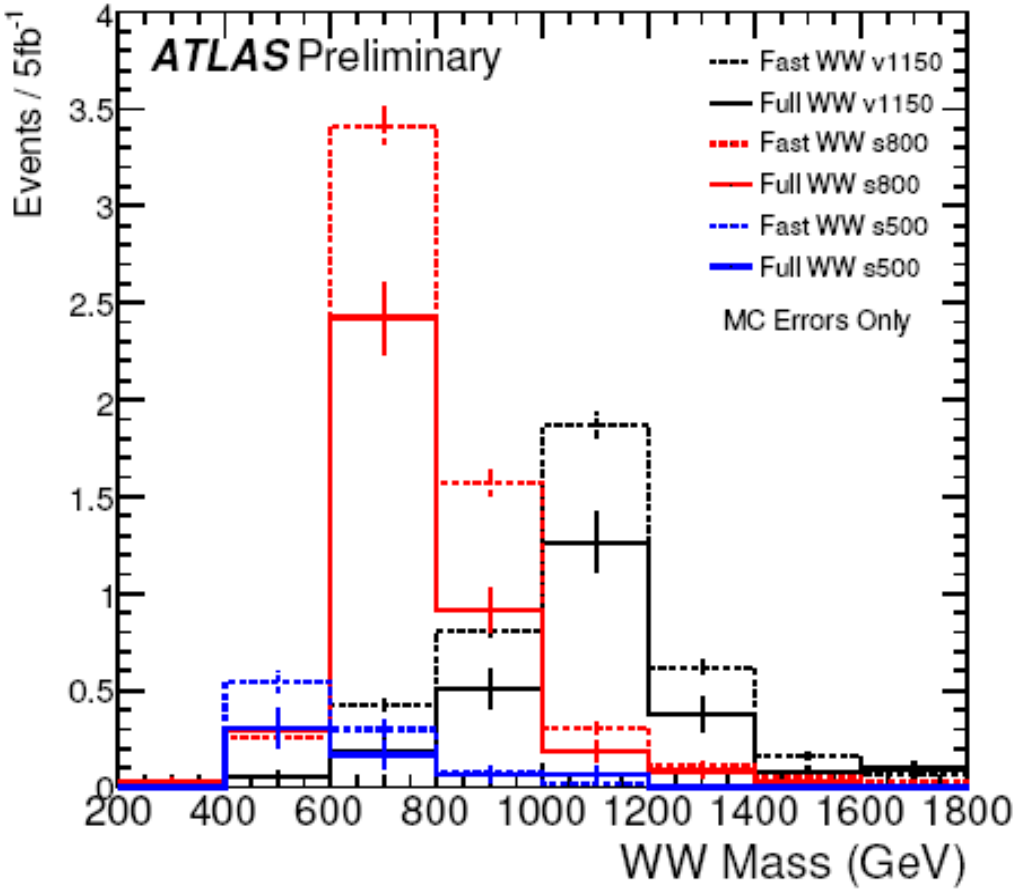
Cut	Reconstruction Efficiency (%)	Trigger Efficiency (%)	Signal σ (fb)	$t\bar{t}$ σ (fb)	W + Jets σ (fb)	Sig/B
Starting sample generated	–	–	(28)	249000	37000	
$\equiv$ 1 Hadronic W	28.4 ± 0.5 (32)		(9.0)	3100 (3700)	(644)	
$\equiv$ 1 Leptonic W	54 ± 1 (73)		(6.6)	1400 (1700)	(294)	
p_T (Had. W) > 200 GeV	99.9 ± 0.1 (100)		(6.6)	1300 (1700)	(290)	
$\lvert\eta\rvert$ (Had. W) < 2	96.3 ± 0.5 (96)		(6.3)	1200 (1500)	(220)	
p_T (Lep. W) > 200 GeV	92 ± 1 (92)		(5.8)	400 (600)	(120)	
$\lvert\eta\rvert$ (Lep. W) < 2	96 ± 1 (95)		(5.5)	400 (500)	(86)	
$\equiv$ 2 tag jets	45 ± 1 (51)		(2.8)	20 (100)	(25)	
$\equiv$ 0 top candidates	49 ± 2 (41)	99 ± 1	(1.2)	< 20 (< 10)	(6.3)	

Table 16: Efficiencies of the cuts for the 800 GeV resonant $qqWW \rightarrow qql\nu qq$ sample. The trigger efficiency column shows the efficiency of mu20i || e25i || jet160 signatures on the sample after each of the cuts have been consecutively applied.

Uh oh...

An Example Invariant Mass Spectrum

- Rather unoptimised
- Single Jet mode only (not good for 500GeV)
- Event counts low



Status of CSC Note

- Collaborating with WZ analysis at Montreal
- Need to do some optimization before it's final
- But unless we live in a model with a very high WW scattering cross-section then measurement probably not possible with CSC lumi ($< 5 fb^{-1}$)
- Early data will realistically be used for calibration and background study, especially single jet mass

What's Going On?

- Trying to finish CSC note
- Working on analysis software
  - Was EventView this time
  - Still evaluating what post-CSC analysis will use
- Working closely with Jet performance group
  - Gradually working YSplitter upstream
  - By release 14, might be getting there

Summary

- WW scattering is interesting
- CSC note is drafted
- Now in optimization/editing phase
- Will have something done by the CSC deadline
- Now looking toward post-CSC work
- YSplitter hopefully fully integrated by release 14

Veto

- Top Veto
  - Reco W candidates with any jet
  - Do leptonic and hadronic
  - Window is 130-240GeV
- Central Jet Veto
  - No jets with pt > 50GeV in |eta| < 2
  - Obviously except for W candidate jet

Had W Cuts

- Y window is 35-100 GeV
- Mass window is centred at 82.8 GeV, allow 14.4 GeV each side (2 sigma)