Motivations For A Specialised W Mass Trigger at ATLAS

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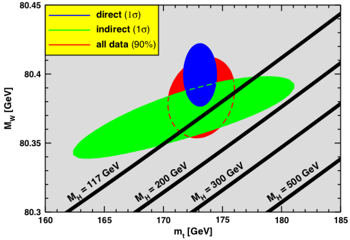
Motivations for the W mass measurement

- Probe predictions of Electroweak Theory
- M_W and M_{top} handles to further constrain EW sector
- M_W currently largest uncertainty on Higgs mass
- Probe masses and EW couplings of new hypothetical particles



Previous World Measurements

Current World Average by Particle Data Group

- 80.399 ± 0.0023 GeV
- Does not include latest Moriond results from CDF and D0.

World Leading measurement by CDF

- 80.387 ± 0.0019 GeV

Final Measurement of ATLAS

- Aims for error of 7 MeV
- 10 fb^{-1} at 14 TeV gives statistical errors of ~ 1 MeV
- Systematic errors need to be ~ 5 MeV

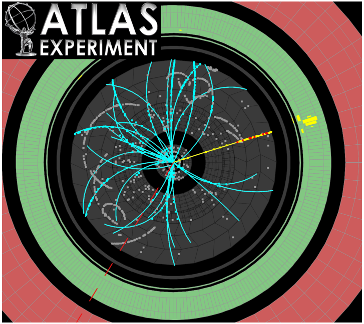
ATLAS egamma triggers

Electron identification

- The triggers use a combination of calorimeter shower shapes and tracking cuts to identify electrons.

Tracking cuts

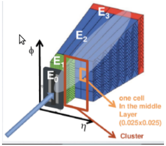
- Number of hits on each track.
- Amount of transition radiation left in the transition radiation tracker.
- Transverse impact parameter cut.
- How closely the track matches to a cluster in the electromagnetic calorimeter.



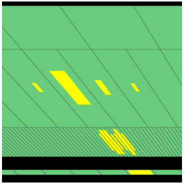
ATLAS egamma triggers

Shower shape cuts

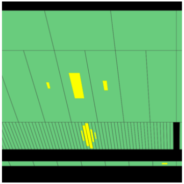
- Shower shapes for electrons - narrower and more focused than the shower shape of fakes. Remove showers with a large spread in eta.
- 2 large energy deposits in finely binned 1st layer - likely to be from pi 0 decay. Remove if two maxima of similar energy.
- Energy from jets leaks out into hadronic calorimeter. Remove showers with large leakage into the hadronic calorimeter and large amounts of energy in the 3rd sampling of EM calorimeter.



Calorimeter



pi 0 shower



Electron shower

ATLAS single electron triggers

Changes for 2012 (compared to 2011)

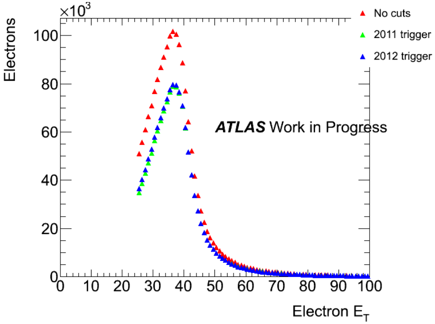
- Additional pile up will affect electron shower shapes, causing a decrease in electron identification efficiency.
- Cuts were loosened on these pile up sensitive variables and cuts on pile up robust variables were added or tightened.
- E_T threshold raised.

W mass trigger plans

- Interested in the identification efficiency of trigger in selecting reconstructed electrons from W decay.
- If the trigger is biased with respect to E_T - will change the shape of the Jacobean peak we fit to measure W mass.
- Are these triggers biased in efficiency vs E_T? If so - can we design a new trigger that has a flatter efficiency?

E_T for 2011 and 2012 triggers

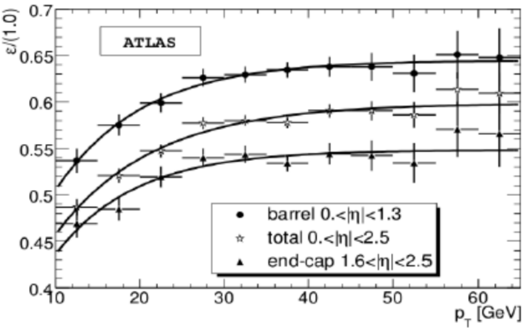
- Use sample of reconstructed electrons matched to truth electrons from W decay.
- Calculate efficiency of electrons passing trigger vs E_T.



Constraining systematic errors

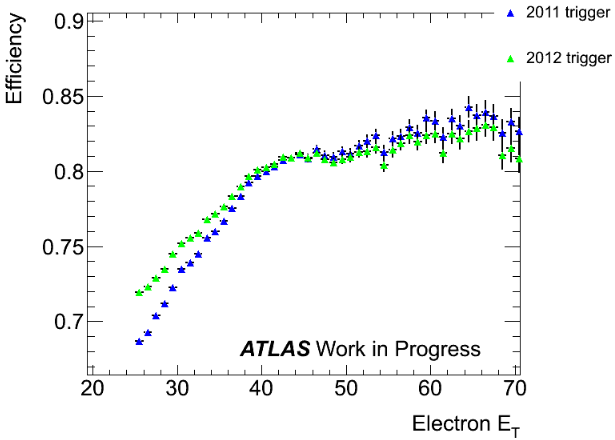
From earlier studies:

- If flat efficiency was assumed, a 9% drop in efficiency of tight electron identification from 40 GeV to 20 GeV would bias the W mass fit by 360 MeV.
- Corresponding to a bias of 4 MeV per 0.1%
- Efficiency drop must be monitored to within 1% relative to keep the systematic <4MeV.
- Any reduction in this slope will relax this constraint by a similar factor.



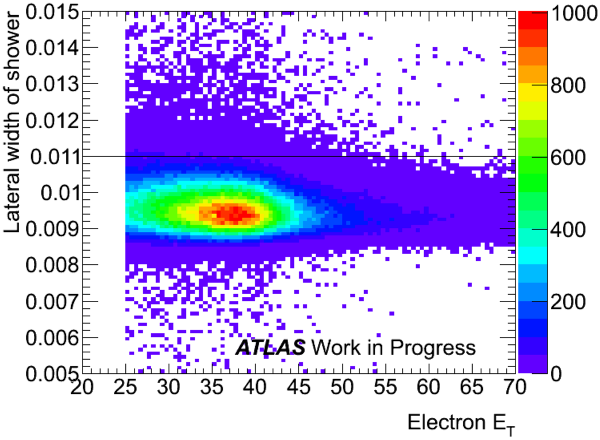
Efficiency vs E_T for 2011 and 2012 triggers

- Efficiency drop is smaller for the 2012 trigger.
- Still larger than is ideal for W mass measurement.



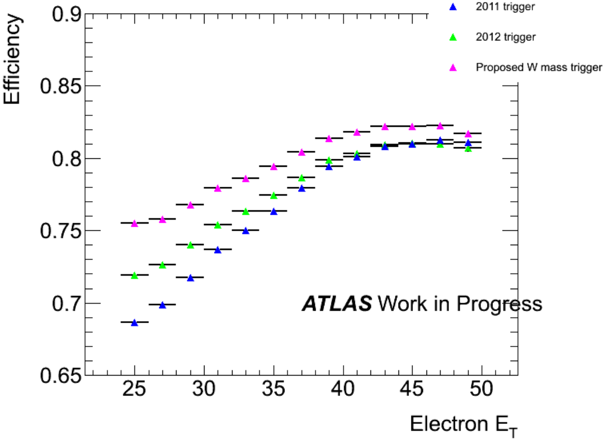
Reoptimising cuts

- For each eta bin and each variable, cuts must be retuned.
- Cuts on the spread of shower shapes proved to be biasing in E_T. Some of these must be loosened.



Reoptimised trigger for W mass

- By loosening some of the cuts on shower shapes, a trigger with a much flatter efficiency can be achieved.

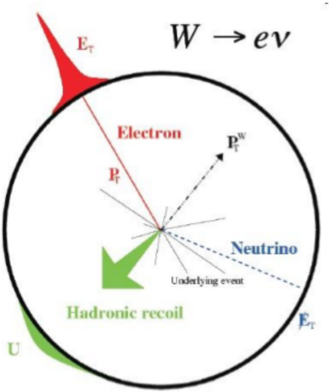


Reducing rates

- Loosening of cuts results in high trigger rates. In order for the specialised W mass trigger to be accepted into the menu it must have minimal extra rate compared to the single electron trigger - of order 1-2 Hz.
- Add cuts on $E_T < 70$ GeV.
- $E/p < 2$ (where E is energy measured in the calorimeter and p is the track momentum measured in the inner detector)
- Removing the highest eta bins, where electrons will be less well reconstructed.

Reducing rates

- Adding a cut on recoil - where Recoil = |vec(e) + vec(MET)| (only transverse quantities will be used). Events with a high W P_T would smear W mass Jacobean peak - undesirable.



Summary

- A bias in the identification efficiency of the trigger with respect to E_T will change the shape of the Jacobean peak fitted in the W mass measurement.
- Any bias must be understood to a high precision.
- Minimising the bias will relax this constraint.
- 2012 unprescaled single electron trigger is biased with respect to E_T.
- Have designed a new minimally biasing trigger for the W mass measurement.

Backup

From "Reevaluation of the LHC potential for the measurement of m_W" Eur.Phys.J.C 57:627-651,2008

Source	Effect	$\partial m_W / \partial_{rel} \alpha$ (MeV/%)	$\delta_{rel} \alpha$ (%)	δm_W (MeV)
Prod. Model	W width	1.2	0.4	0.5
	y^W distribution	–	–	1
	p_T^W distribution	–	–	3
	QED radiation	–	–	<1 (*)
Lepton measurement	Scale & lin.	800	0.005	4
	Resolution	1	1.0	1
	Efficiency	–	–	4.5 (e) ; <1 (μ)
Recoil measurement	Scale	–	–	–
	Resolution	–	–	–
Backgrounds	$W \to \tau\nu$	0.15	2.5	2.0
	$Z \to \ell(\ell)$	0.08	2.8	0.3
	$Z \to \tau\tau$	0.03	4.5	0.1
	Jet events	0.05	10	0.5
Pile-up and U.E				<1 (e); $\sim 0(\mu)$
Beam crossing angle				<0.1
Total (p_T^ℓ)				~7 (e); 6 (μ)

Backup

From "Reevaluation of the LHC potential for the measurement of m_W" Eur.Phys.J.C 57:627-651,2008

Source	Effect	$\partial m_W / \partial_{rel} \alpha$ (MeV/%)	$\delta_{rel} \alpha$ (%)	δm_W (MeV)
Prod. Model	W width	3.2	0.4	1.3
	y^W distribution	–	–	1
	p_T^W distribution	–	–	1
	QED radiation	–	–	<1 (*)
Lepton measurement	Scale & lin.	800	0.005	4
	Resolution	1	1.0	1
	Efficiency	–	–	4.5 (e) ; <1 (μ)
Recoil measurement	Scale	-200	–	–
	Resolution	-25	–	–
	Combined	–	–	5 (**)
Backgrounds	$W \to \tau\nu$	0.11	2.5	1.5
	$Z \to \ell(\ell)$	-0.01	2.8	0.2
	$Z \to \tau\tau$	0.01	4.5	0.1
	Jet events	0.04	10	0.4
Pile-up and U.E				<1 (e); $\sim 0(\mu)$
Beam crossing angle				<0.1
Total (m_T^W)				~8 (e); 7(μ)

Table 4: Breakdown of systematic uncertainties affecting the m_W measurement, when using the p_T^ℓ distribution (top) and the m_T^W distribution (bottom). The projected values of $\delta_{rel}\alpha$ are given for a single channel and assume an integrated luminosity of 10 fb^{-1}. The QED induced uncertainty (*) is realistic given the precision claimed for the Z boson mass measurement at LEP1, but assumes that the needed theoretical tools will be implemented in time for the measurement. The recoil measurement uncertainty (**) has not explicitly been quantified here, but is conservatively extrapolated from recent Tevatron experience. See text for discussion.