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Electron Reconstruction and Identification with the ATLAS Detector

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The understanding of the reconstruction and identification of electrons will be one of the key issues at the start-up of data-taking with the ATLAS experiment at the LHC in 2009. The energy measurement of electrons is based on the electromagnetic calorimetry over most of the relevant energy range (20 GeV to a few TeV). The electromagnetic calorimeter cluster algorithm starts from electronically calibrated calorimeter cells where local position and energy variations are then corrected for. A refined calibration procedure, developed and validated over years of test-beam data-taking and analysis, strives to identify all sources of energy losses upstream of the calorimeter and outside the cluster and corrects for them one by one (using Monte-Carlo). To achieve this, the material in front of the calorimeter will have to be mapped out precisely using other methods. The electron identification is based on the shower shapes in the calorimeter and relies on the tracker and combined tracker/calo information to achieve the required rejection of 10^5 against QCD jets for a reasonably clean inclusive electron spectrum in the moderate p_T region of 10 to 50 GeV. The required rejection factor is closer to a thousand per jet to cleanly extract the signal expected from di-electron resonances in the TeV mass range. The electron calibration and identification methods as well as their performance are discussed here.

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For the ATLAS experiment to achieve its physics goals, the linearity of response of the electromagnetic calorimeter must be better than 0.5 % over a large energy range (5 GeV to 5 TeV). The ATLAS detector and its electromagnetic calorimeter are described elsewhere [1]. Understanding the position and amount of upstream material is essential since more material leads to larger energy losses for electrons and a higher number of photons converting which affects both the energy reconstruction and the identification of electromagnetic particles. The electron/photon calibration scheme used by ATLAS is based on the full Monte-Carlo truth information of energy losses inside the detector. Three terms are added up to recover the initial electron energy: the energy deposited in the material in front of the electromagnetic calorimeter (including the material between the presampler and the first layer of the calorimeter), the energy deposited by the shower in the electromagnetic calorimeter as well as the energy leakage at the back of it. These three terms are parametrised as a function of the measured energies in the presampler and calorimeter. Figure 1 (left) shows the uniformity/linearity obtained after calibration for electron energies ranging from 25 GeV to 500 GeV and over an η range of 0 to 2.5 [2]. It can be seen from the figure that the goal of 0.5 % can be achieved in realistic Monte-Carlo simulations. It has been shown that similar techniques applied in electron testbeams give equivalent results [3] [4]. Figure 1 (right) shows the level of agreement between Monte-Carlo and data for various upstream material thicknesses in an electron test-beam. It shows the level of understanding that can be achieved on the description of the material and its impact on linearity.

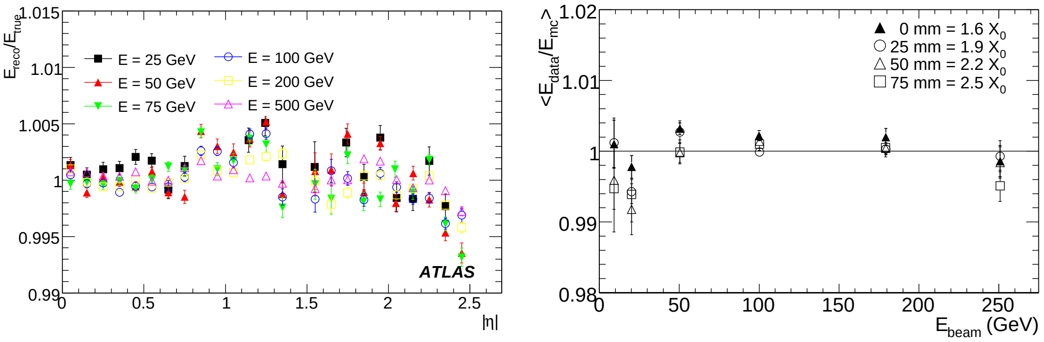

Figure 1: Energy linearity/uniformity vs $|\eta|$ for electrons between 25 and 500 GeV (left). Level of agreement between Monte-Carlo and data in an electron test-beam for different amounts of material added just in front of the electromagnetic calorimeter (right).

Nevertheless, the understanding of the material description in the detector will be of major importance, and strategies are in place for an in situ measurement of the material using photon conversions, electron E/p distributions, and longitudinal shower development. For a precise measurement of the W mass, an even better linearity is required and hence a thorough understanding of the material is mandatory. Other corrections have to be applied to the electron energy and position measurement. The energy corrections account for the energy modulations due to the accordion structure of the electromagnetic calorimeter or out-of-cluster effects close to the cell boundaries. The position corrections account for modulations due to the finite size of the calorimeter cells as well as offsets in the ϕ direction.

The baseline electron identification algorithm in ATLAS relies on rectangular cuts using variables that provide good separation between isolated electrons and QCD jets. These variables include calorimeter, tracker and combined calorimeter/tracker information. A list of all variables used can be found in [2]. They can be applied independently and three reference sets of cuts have been defined: loose, medium and tight. The loose cuts include mainly shower shape variables of the second layer of the calorimeter as well as hadronic leakage variables. In addition to the loose cuts the medium contain variables of the first layer of the calorimeter as well as track quality and track-cluster matching variables. The tight cuts use the full spectrum of relevant variables and in particular E/p cuts and electron identification information from the transition radiation tracker (TRT). Table 1 shows the performance of the cuts in terms of efficiency and QCD jet rejection. A rejection of 10^5 against QCD jets is obtained after the tight TRT cuts providing the experiment with an exceptionally clean inclusive electron sample. It should be noted that the identification cuts as well as the electron reconstruction have been improved recently and a higher efficiency for similar rejections is expected.

Cuts	$E_T > 17$ GeV			$E_T > 8$ GeV		
	Efficiency (%)		Jet rejection	Efficiency (%)		Jet rejection
		$b,c \to e$		Single electrons (E_T =10 GeV)	$b,c \to e$	
Loose	87.96 ± 0.07	50.8 ± 0.5	567 ± 1	75.8 ± 0.1	55.8 ± 0.7	513 ± 2
Medium	77.29 ± 0.06	30.7 ± 0.5	2184 ± 13	64.8 ± 0.1	41.9 ± 0.7	1288 ± 10
Tight (TRT.)	61.66 ± 0.07	22.5 ± 0.4	$(8.9 \pm 0.3)10^4$	46.2 ± 0.1	29.2 ± 0.6	$(6.5 \pm 0.3)10^4$
Tight (isol.)	64.22 ± 0.07	17.3 ± 0.4	$(9.8 \pm 0.4)10^4$	48.5 ± 0.1	28.0 ± 0.6	$(5.8 \pm 0.3)10^4$
	Fraction of surviving candidates (%)			Fraction of surviving candidates (%)		
	Isolated	Non-isolated	Jets	Non-isolated		Jets
Medium	1.1	7.4	91.5 (5.5 + 86.0)	9.0		91.0 (5.0 + 86.0)
Tight (TRT)	10.5	63.3	26.2 (8.3 + 17.9)	77.8		22.2 (7.1 + 15.1)
Tight (isol)	13.0	58.3	28.6 (8.7 + 19.9)	75.1		24.9 (6.4 + 18.5)

Table 1: Expected efficiencies for isolated and non-isolated electrons and corresponding jet background rejections for the four standard levels of cuts used for electron identification. The results are shown for the simulated filtered di-jet and minimum-bias samples, corresponding respectively to E_T-thresholds of 17 GeV (left) and 8 GeV (right). The three bottom rows show the fractions of all surviving candidates which fall into the different categories for the medium cuts and the two sets of tight cuts. The isolated electrons are prompt electrons from W, Z and top-quark decay and the non-isolated electrons are from b, c decay. The residual jet background is split into its two dominant components, electrons from photon conversions and Dalitz decays (first term in brackets) and charged hadrons (second term in brackets). The quoted errors are statistical. This table and caption is taken from [2].

References

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