Electron and Photon Reconstruction and Identification with the ATLAS Detector

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Tracking and calorimetry

**Tracker (|\eta|<2.5)** 3 sub-detector:
- Pixel (97.5%) (3 layers)
- SCT (99.3%) : Semiconductor Tracker (8 layers)
- TRT (98.0%) (|\eta|<2.0): Transition Radiation Tracker (straw tube, ~30 hits for track)

**Calorimeter EM (|\eta|<3.2) (98.5%)**
- Pb-Lar Sampling calorimeter (87K)
- Barrel + 2 EndCaps
- Accordion for full Φ coverage
- ~170k channels

*(operational fraction of detectors)*
Reconstruction & Identification

Reconstruction:

- Calorimeter cells calibrated at EM scale:
  - Build a fixed sized cluster with sliding window algorithm

Tracker:

- Matching track
  - Electron

Conversion vertex

- No matching track
  - Photon

→ Rebuilds the clusters with object adapted size
→ Apply the dedicated object energy calibration

Identification:

cut based. Discriminating variables from

- Hadronic calo: leakage
- EM calo: shower shape in 1st and 2nd samplings
- Track: track quality (hits) + TRT (hits, fraction)
- Cluster/track matching
Expected reconstruction performance from MC

- Linearity: better than 0.5% for both electrons and photons
- Energy resolution:

→ Energy resolution is influenced by the amount of material in front of calorimeter
→ First checks of material estimates with energy flow and photon conversions
Energy Flow from Minimum Bias Events

- Check EM calo response of all channels to physics:
  - Occupancy maps ($E>5\sigma$)
  - White squares are known dead readout regions
  - Study revealed one readout cabling inversion and high voltage cable swaps now corrected for

- Probe of total amount of upstream material

  $$R = \frac{Occ_{\phi,\eta-slice} - \langle Occ_{\eta-slice} \rangle}{\langle Occ_{\eta-slice} \rangle}$$

  Up to $1X_0$ lack of material observed in localised regions close to the rails supporting the ID. Can be fed in an updated geometry description

  Good agreement for the rest of the barrel
ID rails
Photon conversions

- Distribution of reconstructed conversions as a function of the radius and the longitudinal position of the reconstructed conversion vertex.

- Allows to spot some data/simulation discrepancies. Example: pixel global support at ~200 mm is shifted by ~1 cm in radius.

- Shift also visible on the 1D plots:

- Relying on the TRT response:

09/06/10  IPRD 2010 - Electron and Photon Reconstruction and Identification with ATLAS
$\pi^0$ reconstruction @ $\sqrt{s} = 7\text{TeV}$

- $\pi^0 \rightarrow \gamma\gamma$ peak was extracted with clustering and calibration algorithms optimised for low energy $\gamma$
  - Mass reconstruction:
    - Mass (MeV): 135.04 +/- 0.04
    - Resolution (MeV): 20.80 +/- 0.06
    - Data/MC agreement better than 1%

- $\eta$ and $\phi$ uniformity:
  - Data/MC agreement within 2% for barrel and endcaps

Also reconstructed with conversions:

- $\eta$ and $\phi$ uniformity:
  - Data/MC agreement within 2% for barrel and endcaps

- Ratio Data $\pi^0$ mass / MC $\pi^0$ mass

- Mass (MeV): 135.04 +/- 0.04
- Resolution (MeV): 20.80 +/- 0.06
- Data/MC agreement better than 1%

ATLAS Preliminary
Electrons @ $\sqrt{s} = 7$TeV

- ~1nb$^{-1}$: 128,909 preselected electrons compared to a 10 million non-diffractive minimum bias events, background broken into its different components
- Identification cuts:
  - **loose**: hadronic leakage, shower shape in 2$^{nd}$ sampling
    - 68% hadrons, 28% electrons from conversions, 4% prompt electrons
  - **medium**: loose + S1 shower shape + track quality + cluster/track matching
    - 66% hadrons, 23% electrons from conversions, 11% prompt electrons
  - **tight**: medium + high threshold TRT hits + conversion veto
    - 30% hadrons, 22% electrons from conversions, 48% prompt electrons

- Additional cuts on energy fraction in 1$^{st}$ sampling (good hadron/electron discriminant at low $p_T$): hadrons contribution drops to < 15%

- **hadrons**
- **electron from $\gamma$-conversions**
- **prompt electron mostly from b, c decays**
Electrons @ $\sqrt{s} = 7$TeV

Calorimetric variables:

- **Hadronic leakage**
- **Shower width in S2**
- **Shower confinement in S2**
- **Shower width in S1**

→ Shower larger in the data in 1\textsuperscript{st} and 2\textsuperscript{nd} sampling of EM calo (same observation for photons)
→ Combination of effects from material, cross talk…
→ Good overall agreement for an experiment at its very early stage
Electrons @ $\sqrt{s} = 7\text{TeV}$

- Tracker related variables:

- Number of silicon hits
- Fraction high TRT hits
- Impact parameter
- E/p

- As expected, electrons from conversion correspond to tracks with few hits in the silicon detectors
- Fraction of high TRT threshold hits good hadron discriminant
- Electrons from conversions have a larger impact parameter (conversion occurring at large radii)
- Electron contribution E/p peak closer to unity
- Good data/mc agreement despite the complications expected at low energy due to material effects and track reconstruction inefficiencies
J/ψ observation @ $\sqrt{s} = 7$TeV

- J/ψ$\rightarrow$ee was observed with a cluster reconstruction optimised for low energies.
  - Clusters-tracks matching and discriminating variables are standard (shower shape + track quality). Strict requirements are applied to the fraction of high threshold hits in the Transition Radiation Tracker.
  - Invariant mass is computed using track parameters only. The track momenta are not corrected for bremsstrahlung effects.

**Mass reconstruction:**
Fitting function: asymmetric gaussian (signal) + straight line (background)
Fitted Mass (MeV): $3052 \pm 0.065$
Fitted Width (MeV): $270 \pm 0.045$

$Mass(PDG) = 3096.916$ MeV
W reconstruction @ √s = 7TeV

- Total integrated luminosity of 6.69 nb⁻¹. Expected total number of events: 21.9 ± 0.6(stat) ± 1.5(syst) ± 4.1(lumi)
- Full electron identification (cuts on calorimeters and tracker variables, cluster/track matching), $E_T^{\text{electron}}>20\text{GeV}, E_T^{\text{miss}}>25\text{GeV}$
  - 17 $W\rightarrow e\nu$ candidates
- Electron cluster $E_T$ distribution and transverse mass $m_T$ of selected candidates:

![Graph showing electron cluster $E_T$ and transverse mass $m_T$ distributions.](image-url)
W→ev and Z→ ee candidates events displays

1.6 ± 0.1(syst) ± 0.3(lumi) Z→ ee events expected
Conclusions

- In 2010, ATLAS has been collecting LHC collisions data at $\sqrt{s} = 7$TeV
- Material estimations in the inner detector were checked with photon conversions vertex position, complementarily to the energy flow from minimum bias events for material at larger radii
  → A fair agreement with the Monte Carlo model has been observed, with a few isolated problems spotted
- Calorimetric and tracker related electron identification variables are in a general good agreement with simulations. Remaining discrepancies under investigation.
- $\pi^0 \rightarrow \gamma \gamma$ and $J/\psi \rightarrow ee$ peaks were observed with a reconstructed mass in good agreement with Monte Carlo and PDG value.
- 17 $W \rightarrow e\nu$ candidates and one $Z \rightarrow ee$ candidate have been observed

The ATLAS electron and photon reconstruction and identification performance at $\sqrt{s} = 7$TeV gives confidence in the very good potential of electromagnetic physics for early analysis at the LHC