e/γ reconstruction & identification in ATLAS

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Physics at LHC 08 - Split, Croatia

Electrons and photons

High identification efficiency
High jet rejection

Percent energy resolution
Permil energy scale

Soft–e identification
(b–tag)

$Z \rightarrow ee$
$W \rightarrow e\nu$
$H \rightarrow 4e$
SUSY cascades
$H \rightarrow \gamma\gamma$
$G \rightarrow \gamma\gamma$
$Z' \rightarrow ee$
Material map.

Good η resolution
(pointing)

Bremsstrahlung recovery

Early and late γ reconstruction

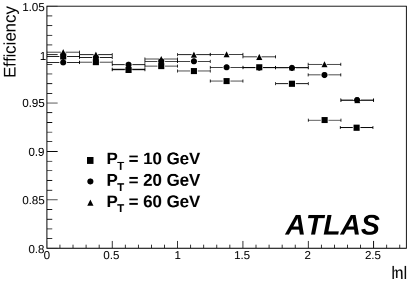
Tracking

3 algorithms in parallel :

- Outward : seed in Pixel/SCT and extrapolate out to TRT
- Inward : seed in TRT and extrapolate in to Pixel/SCT
- TRT standalone (useful for conversion id.)

Single electron tracking efficiency

Versus η



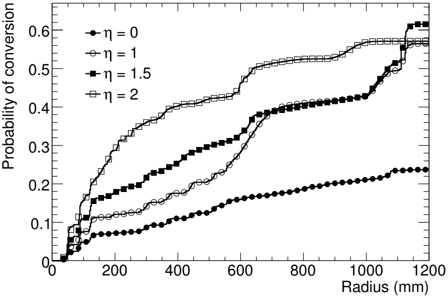
Versus p_T

p_T (GeV)	10	20	60
Eff. (%)	97	99	98

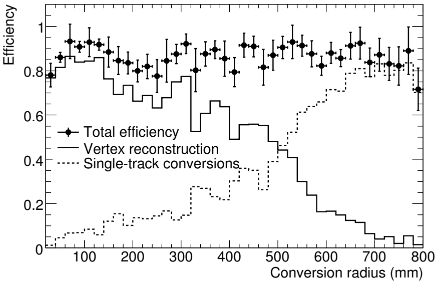
Some energy lost by bremsstrahlung
Partially recovered by various algorithm
(Gaussian Sum Filter, Dynamic Noise Adjustment)

Conversions

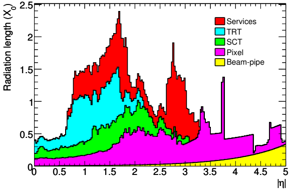
Conversion probability



Conversion reconstruction efficiency



- 20–60 % probability for photons to convert before calorimeter
- important for $H \to \gamma\gamma$ and material mapping
- $R_c < 50$ cm $\to$ vertices efficiently reconstructed
- Further out $\to$ look for single TRT tracks



Calorimetry

Two complementary approaches : calo. (high–p_T) or track seeded (low–p_T).

Calorimeter seeded :

- Cluster around seed ($E_T > 3$ GeV)
- Match clusters to tracks ($\Delta\eta$, $\Delta\phi$ and E/p) and conversions
  - Track matched : electron
  - No track matched : photon
  - Track matched but in conv. : converted photon
- Calibrate cluster size : 0.075×0.175 for electrons and 0.075×0.125 for photons in barrel ($|\eta| < 1.4$). 0.125×0.125 for $|\eta| > 1.4$.
- Identification
  - η, E_T dependent cuts.
  - Multivariate : likelihood ratio, H–matrix

Track seeded : extrapolate tracks to calo., build and calibrate clusters.

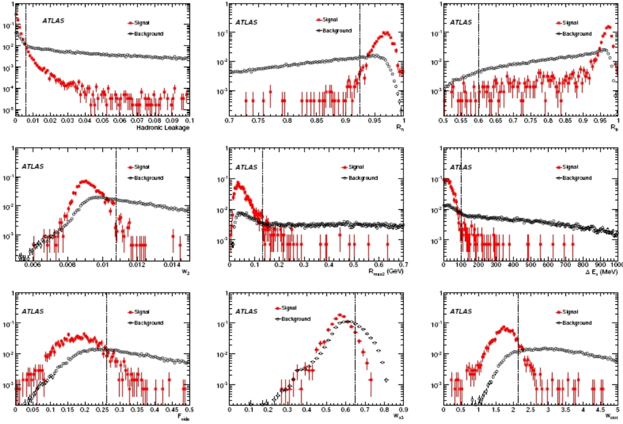
Approaches can be confronted for early data cross–checking.

For e and γ

- Hadronic leakage
- Shape in first sampling
- Shape in middle sampling
- Cluster isolation

For electrons only

- Track quality
- Track match
- TRT hits count and ratio of high threshold hits



Plots for photons

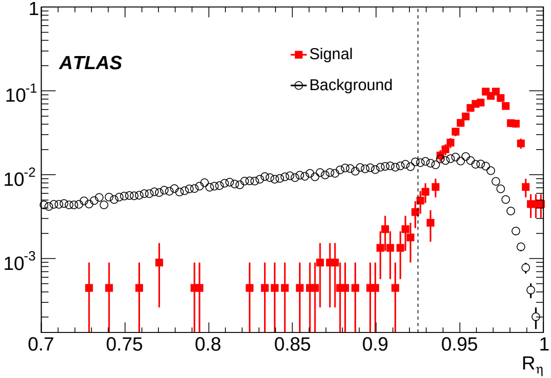
Identification variables

For e and γ

- Hadronic leakage
- Shape in first sampling
- Shape in middle sampling
- Cluster isolation

For electrons only

- Track quality
- Track match
- TRT hits count and ratio of high threshold hits



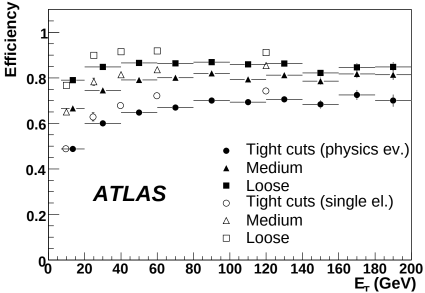
Plots for photons
($|\eta| < 0.3$ and $20 < E_T < 30$ GeV)

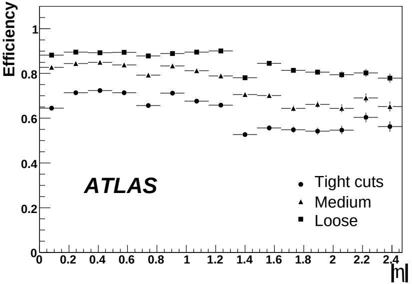
Cut–based identification

Electrons

- Apply E_T–η dependent cuts
- 3 qualities of electrons
- Eff. for SUSY electrons
- Rej. with filtered di–jets
- All candidates have $E_T > 17 GeV$

Quality	cuts	Eff.	Rej.
Loose	hadronic leakage + middle samp.	**88%**	570
Medium	Loose + strips + cl. isolation + trk. quality	**77%**	2200
Tight	all cuts	**64%**	10^5



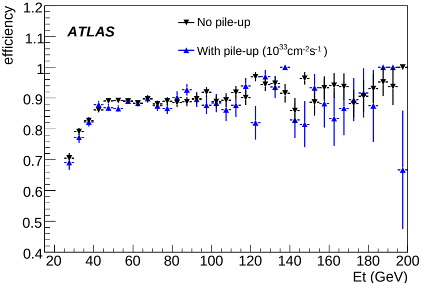


Plots with electrons from SUSY cascades

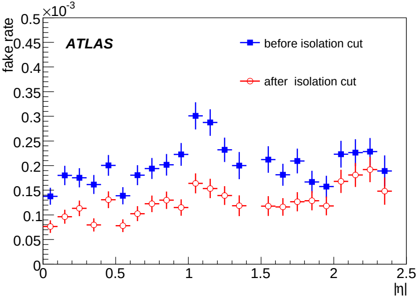
Photons

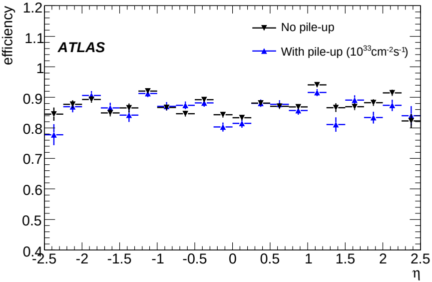
$H \to \gamma\gamma$

- same calorimeter variables used
- Aditional track isolation against π^0
  - Sum of p_T of tracks within $\Delta R = 0.3$ lower than 4 GeV
  - factor of 1.5 to 2 gain on fake rate



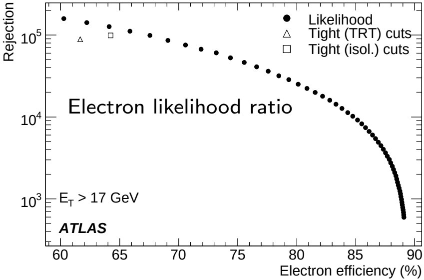
Fake rate

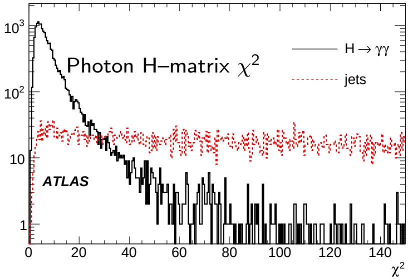




Multivariate identification

- Combine id. variables into multivariates discriminants : likelihood ratio, H–matrix
- 60% higher rejection for same electron efficiency with likelihood ratio
- 10% higher electron efficiency for same jet rejection
- Equivalent performance for photons

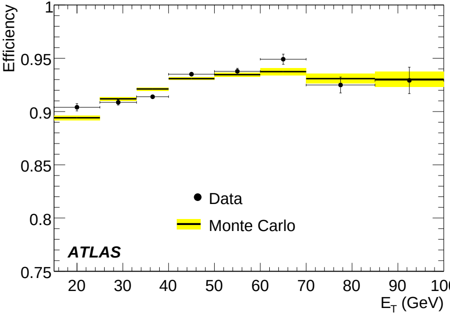


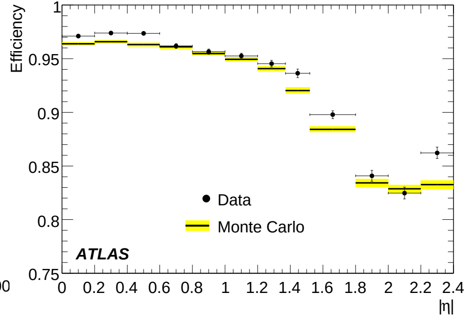


Necessity to determine efficiencies from data ⇒ tag and probe method on $Z \to ee$

Tag and probe method

- Select electron pairs with M_{inv} near m_Z, one of which Tight (tag)
- Measure efficiency for other electron to pass a set of cut





Statistical error of 0.1% with 100 pb^{-1} and systematic of 1–3%

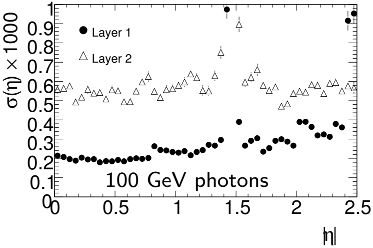
Offline cell calibration

- Correct for electronics non–linearities and non–nominal high–voltage.

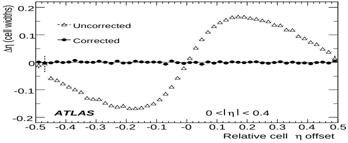
Offline cluster position calibration (derived from detector simulations)

- Energy weighted barycentre. η calib. : S–shape ; ϕ calib : offset.
- 0.3 to 0.4×10^{-3} η resolution for photons (important for pointing).

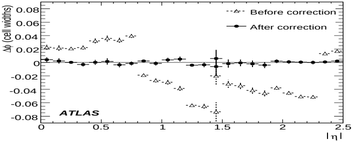
Position resolution



S–shape



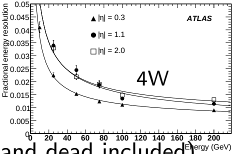
ϕ offset



Calibration

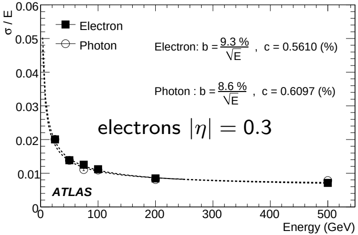
Offline cluster energy calibration (derived from detector simulations)

- *Four–weights method*
  fit the reconstructed energy with parametrization
  $E_{reco} = A(B + W_{ps}E_{ps} + E_1 + E_2 + W_3E_3)$

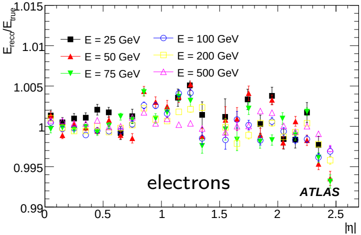


- *Calibration hits method*
  dedicated simulations record deposit in material (active and dead included)
  default calibration method in ATLAS
  E = deposit in the calo. + lost before calo. + long. leak
- 1 to 3 % energy resolution for 100 GeV electrons vs. η.
- Linearity in barrel better than 5 ‰ for $10 < E < 500$ GeV.

Energy resolution (Calib. hits)

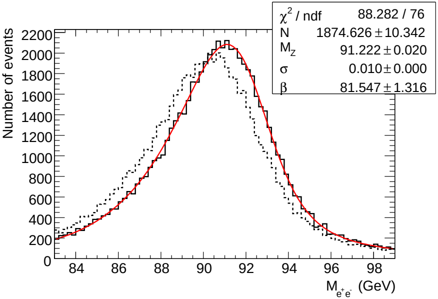


Linearity (Calib. hits)



In–situ intercalibration with $Z \to ee$

- Calorimeter response locally uniform to 0.5%
- Possible to intercalibrate local regions with $Z \to ee$ data
- Provides a constraint on the absolute energy scale
- Requires a good knowledge of the ID material

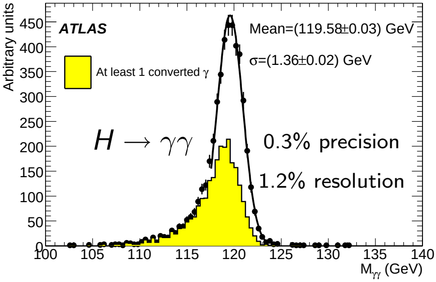


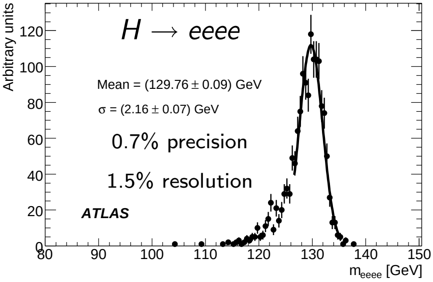
Method

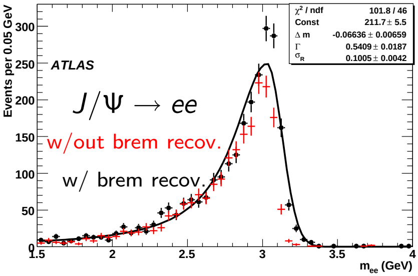
- For each region $E_i^{\text{reco}} = E_i^{\text{true}}(1+\alpha_i)$
- Reference Z line shape = Breit-Wigner $\otimes$ ele resolution $\otimes$ parton lumi.
- fit α_i's to the reference shape
- Correct cells energy offline with α_i's

- Correct central value recovered
- Constant term of 0.7% achievable with 200 pb^{-1}
- Energy scale to 0.2‰

Benchmark processes







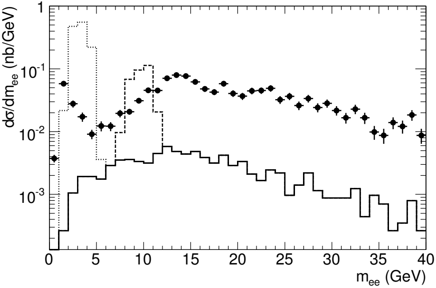
Early data

Large γ–jet signal

- 5×10^6 events expected ($E_T^\gamma > 20$ GeV)
- Measure fake rates from data, efficiency from electrons

Large electron signal from b/c

- Measure fakes using TRT
- MC still needed for efficiency



Large electron pair signal from J/Ψ

- 20k J/Ψ, 5k Υ and 3k Z electron pairs expected ($E_T > 5$ GeV) for 10 pb^{-1}
- Clean signal but low efficiency
- Measure efficiency and confront track/calo–seeded algos.

Summary

- Reasonable id. efficiencies for high jet rejection achieved in ATLAS
  - Combination of calo.–based variables (shower shapes, isolation) and tracks
  - Various id. methods available : cuts, likelihood ratio, H–matrix
- Conversions efficiently identified thanks to vertex and single tracks
- Combination of on/offline cell/cluster calib. and in–situ
- Proper electrons and photons reconstruction and identification necessary for major channels ($Z, J/\Psi, \Upsilon \to ee$, $H \to \gamma\gamma$, $H \to 4\ell$, SUSY 3ℓ).
- On–going works focus on readiness for data
  - Trigger menus for early runs
  - Material mapping with conversions and brem activity
  - Data–driven calibration and efficiency measurement
  - Brem recovery
  - Data access and analysis tools improvements
  - Optimization of id. algorithms for all cases (soft, forward, central...)