Electron trigger performance of the ATLAS detector

G. Navarro
on behalf of ATLAS Collaboration
Universidad Antonio Nariño

Signaling the Arrival of the LHC Era
December 8 – 13 2008

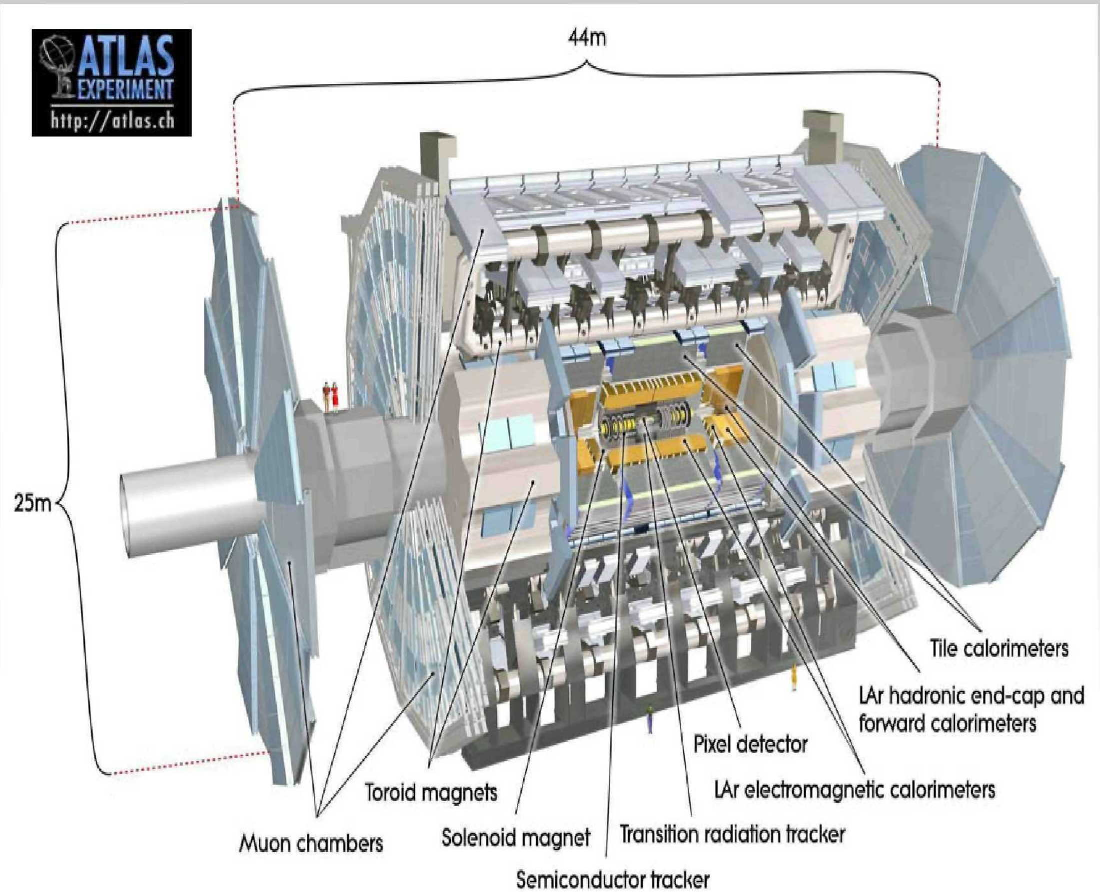
Outline

- Detector overwiew
- Review of the Atlas trigger system
- Electron trigger and physics performance
- Trigger robustness studies
- Trigger efficiency from real data
- Summary

Detector Overview

Overall detector layout

- Magnet configuration
- Inner Detector
- Electromagnetic calorimeter
- Hadronic calorimeter
- Muon spectrometer



The Atlas Experiment at the CERN Large Hadron Collider, ATLAS Collaboration, JINST 3:S08003,2008

Detector Overview

- Bunch crossing rate: 40 MHz.
- ~ 23 interactions per crossing at design luminosity.
- Event data recording → 200 Hz
- Factor of rejection of ~ 10^5.

Trigger must select the right events!!!

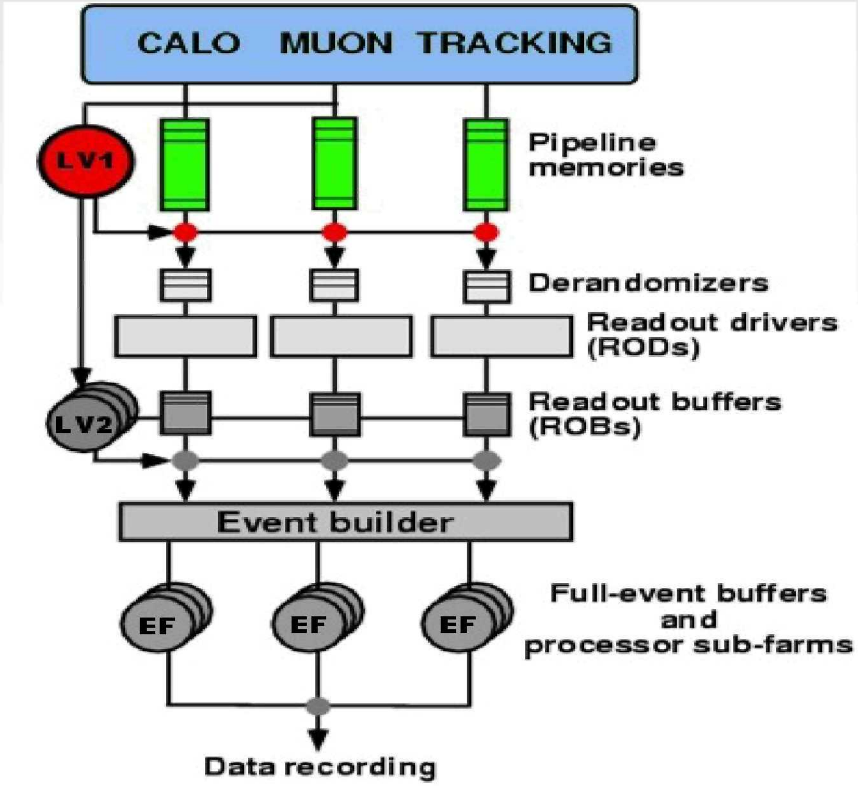
Review of the ATLAS trigger system

Trigger consists of three levels of event selection:

- Level-1 (L1)
- Level-2 (L2) — High level Trigger (HLT)
- Event Filter — High level Trigger (HLT)

L1

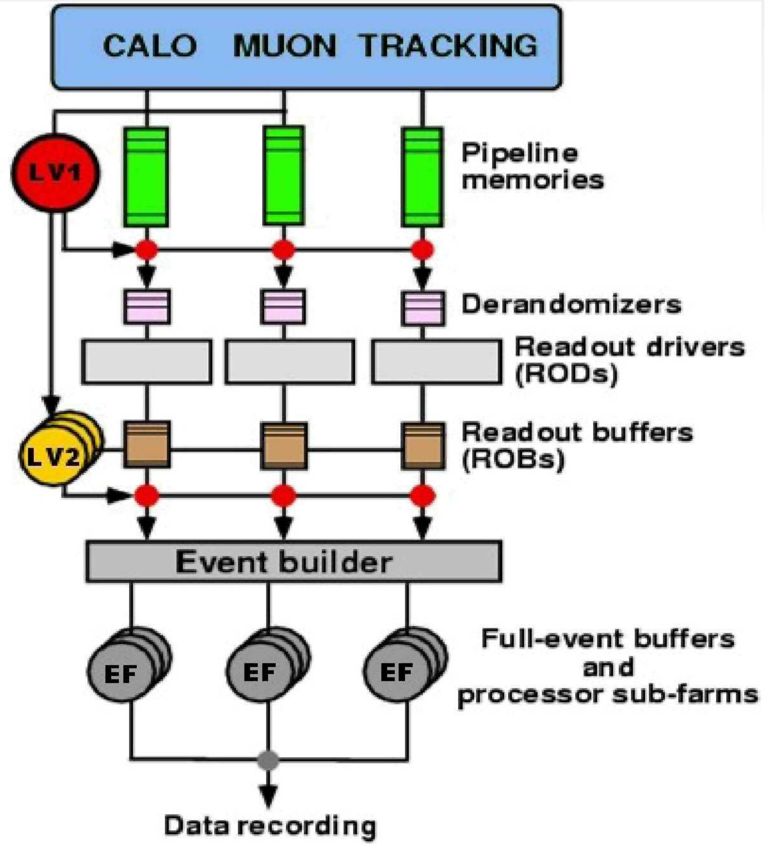
- Searches for :
  signatures from high pT μ, e/γ and τ
  events with large E_T^{miss} and large E_T
- Hardware based
- Uses reduced granularity
- Maximum acceptance rate ~ 75KHz
- Decision must be reached within 2.5 μs after the bunch crossing.



Review of the ATLAS trigger system

HLT

- Uses the full granularity of the calorimeter and muon chamber that improves the threshold cuts
- Uses data from ID → track reconstruction enhances particle identification.



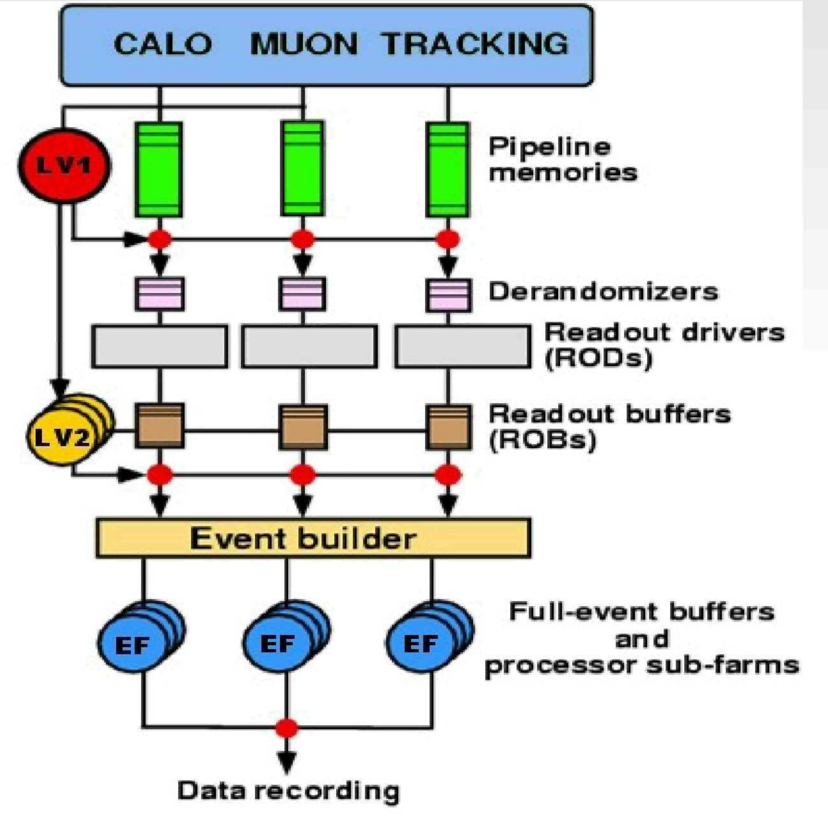
L2

- Seeded by Regions of Interest (RoIs)
- Reduces event rate to ~ 3.5 Khz
- Average event processing time of 40 ms.

Review of the ATLAS trigger system

EVENT FILTER

- Uses offline analysis procedures on fully-built events
- Reduces event rate to ~ 200 Hz
- Average event processing time of 4 seconds.



Electron trigger and physics performance

- Events with electrons in final state are important signatures for many physics analysis

Searches for new physics {
- $H \rightarrow ZZ^* \rightarrow eeee, ee\mu\mu$
- Susy particles decays
- $Z' \rightarrow ee$, $W' \rightarrow e\nu$

SM precision physics {
- top physics
- W mass measurements
- rare B decays

- There are processes involving electrons that will be important for the calibration, alignment and the detector performance monitoring:

  $Z \rightarrow ee$, $W \rightarrow e\nu$, single electron, $J/Psi \rightarrow ee$

Electron trigger must ensure good selection of the above physics channels!!!!!!

Electron trigger and physics performance

- L1 selection

→ Electrons selected using calorimeter → `trigger towers`

→ Algorithm based on a sliding 4x4 window trigger towers which looks for local maxima.

→ Trigger object is considered a candidate if some requirements are satisfied.

- L2 selection

→ Electron selection uses calorimeter information in first step cluster E_T and shower shapes of different layers of the EM calo.

→ Inner Detector information is used: tracks are reconstructed and matched calo clusters.

- EF selection

→ Uses offline reconstruction algorithms.

→ Identification similar to the offline.

Electron trigger physics performance

Expected Performance of the ATLAS Experiment Detector, Trigger and Physics, CERN-OPEN-2008-020

- To reduce the rate it is necessary to impose tight cuts in trigger selection.

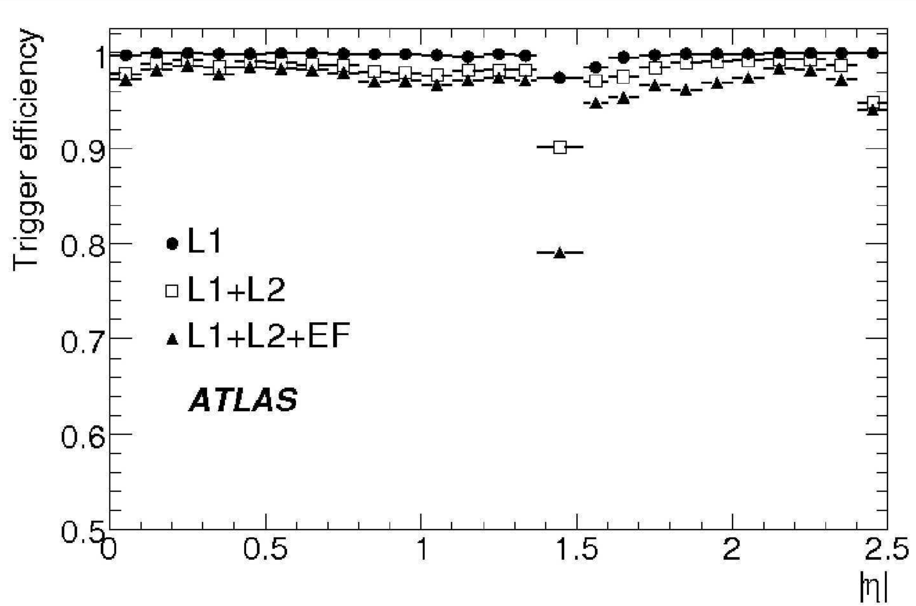
- It is necesary to analyze possible bias in the trigger:
  studies of trigger efficiency plots as function of E_T, η and φ

- Trigger efficiency
  # electrons that pass trigger level / # offline identified electrons

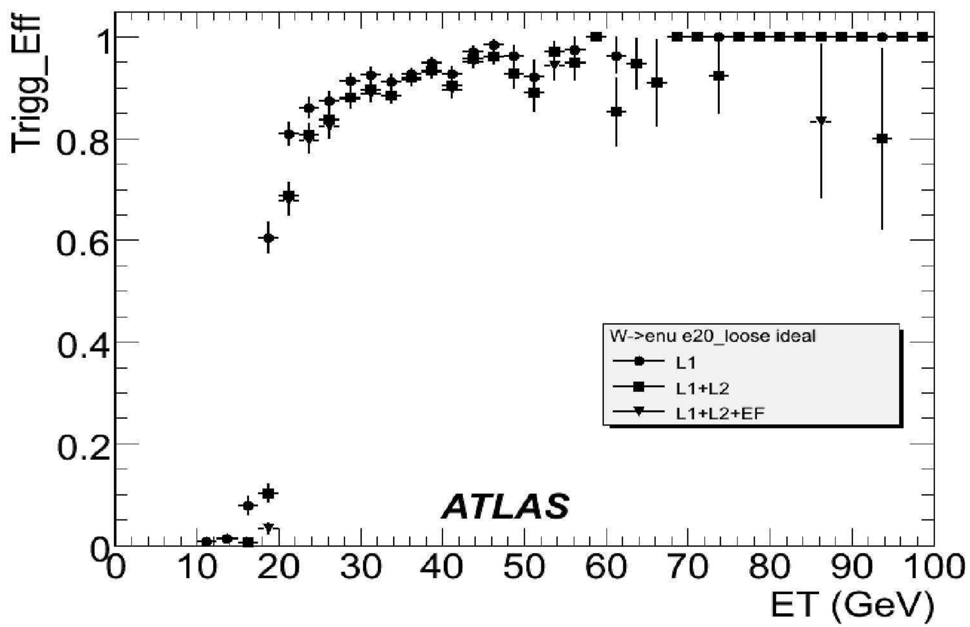
- Trigger efficiencies computed with simulated samples of
  single electron, $Z \rightarrow ee$, $W \rightarrow e\nu$, $J/Psi \rightarrow ee$, etc.

- Signatures studied for start up: e5, e10, e20, e105 for $L = 10^{31}\ cm^{-2}s^{-1}$ and e22i for higher luminosities.

Electron trigger physics performance



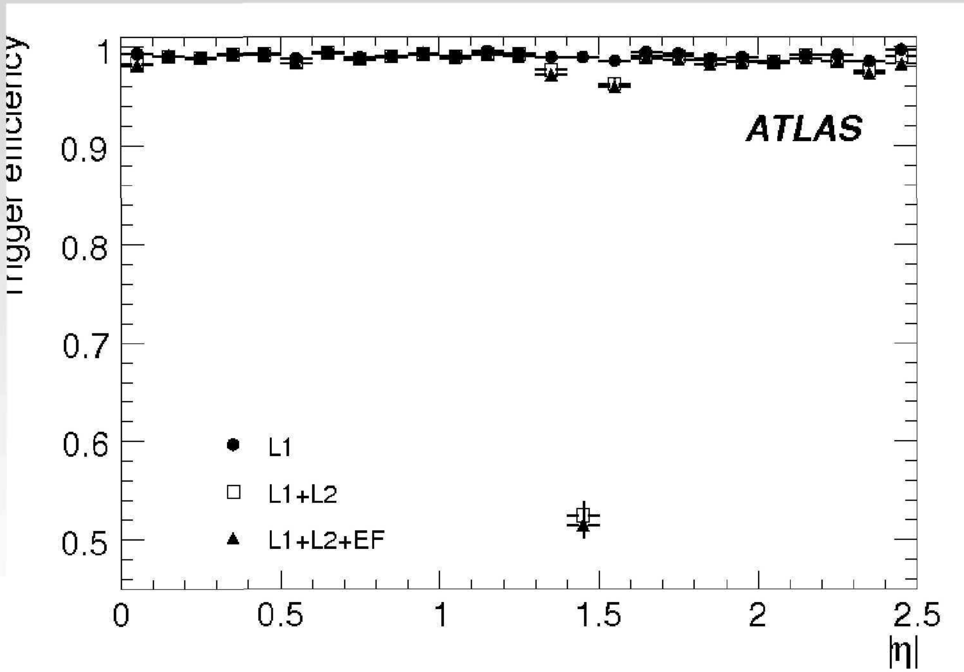
Efficiencies for single electrons ideal geometry sample with 7< E_T<80 GeV for the e10 trigger as a function of η.



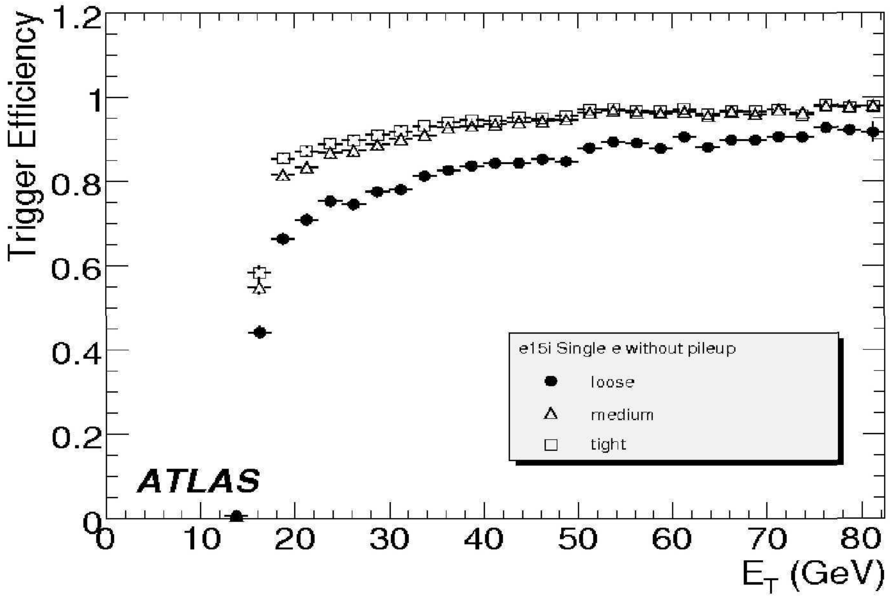
Efficiencies for W $\rightarrow$e ν ideal geometry samples as function of E_T for e20 trigger

Eff. reaches a plateau value for E_T above ~ 30 GeV.

Electron trigger physics performance



- Trigger eff. of the trigger e105 vs. $|\eta|$.
- Trigger aimed at selecting very high p_T electrons.



- Trigger eff. dependency on different offline electron identification cuts.
- Sample: single electron with misalignment and E_T between 7 and 80 GeV.
- Trigger e15i

Trigger Robustness studies

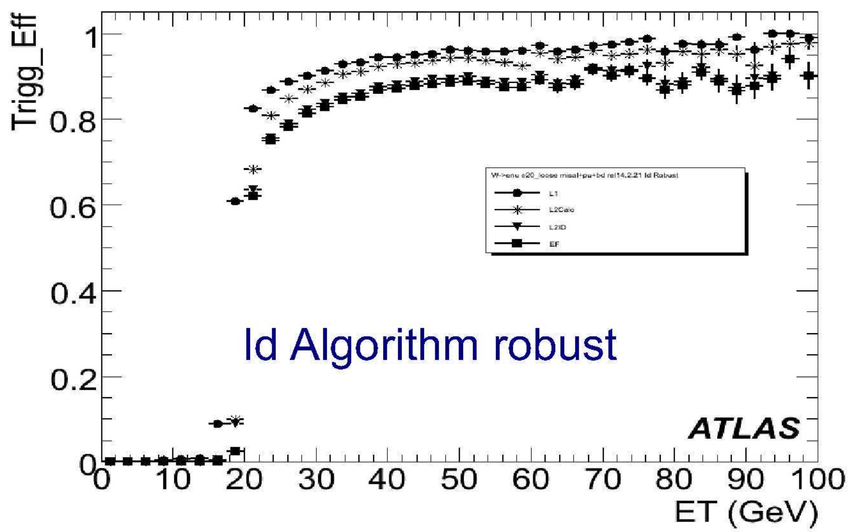
- Effects of pile-up

Trigg. Level	e١٢i w/out pile-up	e١٢i w/ pile-up	e٢٢i w/out pile-up	e٢٢i w/ pile-up
L١	٩٣.٢±٠.٣ %	91.9±0.3 %	95.5±0.1 %	95.1±0.3 %
L١+L٢	86.3±0.4 %	84.7±0.4 %	89.6±0.2 %	88.9±0.4 %
EF	٧٩.٢±٠.٥ %	78.8±0.5 %	88.0±0.2 %	87.5±0.4 %

- Trig. Eff. for the e12i and e22i trigger.
- Samples of single e at $L = 2x10^{33}\ cm^{-2}s^{-1}$ with and without pile-up.
- Difference of 2% in L1 due to isolation cuts.
- 1% loss at HLT.

- Trig. Eff. For W→ eν samples with pile up misalignment and beamspot displacement.

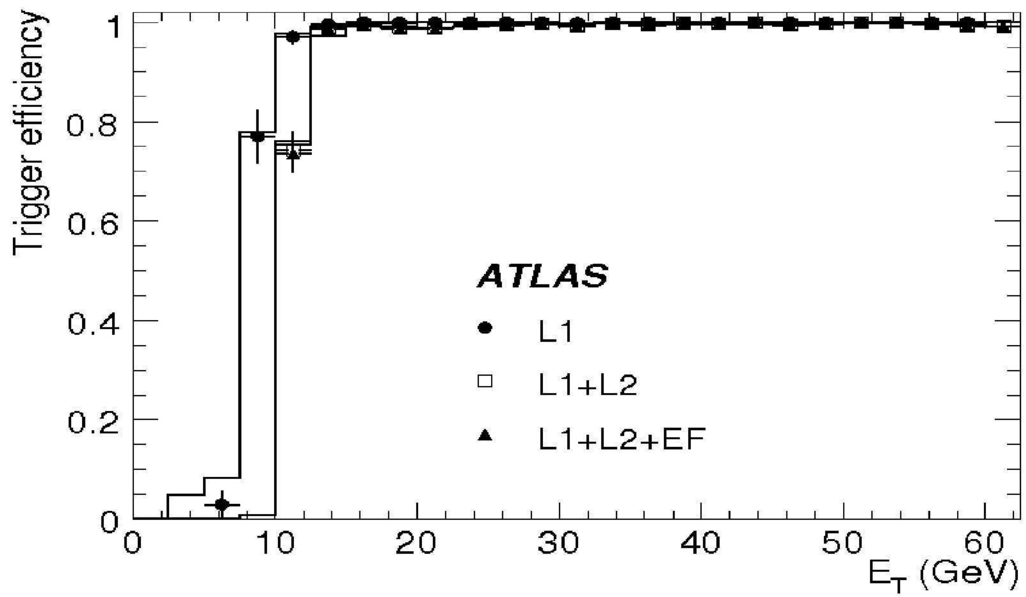
Level	Id reconstruction normal	Id reconstruction robust
L1	92 ± 1%	93.21 ± 0.08%
L1+L2	57 ±2%	85.87 ± 0.11 %
L1+L2+EF	56± 2 %	85.00 ± 0.12 %



Trigger Efficiency from Real Data

Tag and Probe method

- ➔ Uses offline identification of Z→ee decays to select sample of electrons.
- ➔ Electron candidate that satisfies a trigger signature is reconstructed and identified offline "tag electron"
- ➔ Z→ee requires second electron identified offline "probe electron" → used for computing trigg. eff.



Tag and probe for 2e10 trigger.

SUMMARY

- We have reviewed the ATLAS trigger system that has to deal with a reduction of the bunch crossing rate from 40 MHz to 200 Hz.

- As events with electrons in the final state are very important for physics at LHC, it is necessary to identify them properly.

- A short description of the electron identification has been made.

- The performance of the electron trigger has been studied for the basic signatures and menus for the LHC commissioning.

- The robustness of the electron trigger has been tested studying pile up, beamspot displacements, and other possible effects.

- A method for determining the trigger efficiency for real data has been described. The results of a study using a $Z \rightarrow ee$ MC sample shows good performance.