The ATLAS Level-1 Trigger System

L1Calo — Calorimeter Trigger

Inputs (from detector):

• Analogical L1 and Tile calorimeter signals, summed in granularities of 48 × 48 (central region) up to 4 × 4 (forward regions) / 3D Trigger Towers, with over/under and out-of-time layers.

• Digital trigger signals (SCAL), measured deposited transverse energy and perform beam bunch identification.

• Sliding window algorithm to find local energy maxima across rows and compare to trigger settings at different eta regions.

• Summation in depth to form 3D per jet elements, select per jet finding of (E, kT) and whole calorimeter energy summation (E, kT, 8X, 8Xh).

The trigger cross sections, shown right, demonstrate the capabilities of the Level-1 Trigger as luminosity increases. For low trigger thresholds, the L1Calo trigger is dominated by lower layers/detectors. Above 1000 MHz, the L1Calo trigger is sensitive to high energy jet identification and has a four-fold higher rate with respect to the offline trigger.

Figure 6: Distribution of L1_MU11 trigger events, showing event distribution in ET and the fraction of offline trigger events.

LIMuon — Muon Trigger

Inputs (from detector):

• Over 800 hits strips from Resistive-Readout Chambers (RPC), the barrel region has 104 RPCs and 37 TCTP Monitors, the endcap regions (7012–7016) are covered by 367 RPCs, spread over three planes (252 strips) of (detached) doublet chambers.

• Trigger counting for the different thresholds, also suggested a coefficient of four in the pre-long trigger region to the L1- → L2 transition.

Figure 7: Distribution of L1_MU10 trigged events, showing the event distribution in ET and the fraction of offline trigger events.

Multi-Object Trigger Rates

The multi-object or trigger rates with respect to the luminosity (Figure 8, left) can be understood in terms of the number of interactions are being crossing. The probability for a single collision to cause a single object (e.g. a muon) is given by (1 + 3/2z) 
where z is the number of objects crossing the beam. This can be written as 

In Figure 8, the lower multi-object trigger rates (left section) are due to gain within the beam line. Right the newly implemented correction of the trigger rate is shown.

Figure 9: Distribution of L1_XE50 trigger events, showing event distribution in ET and the fraction of offline trigger events.

L1TP — Central Trigger Processor

Inputs:

• Trigger inputs from L1Calo, LIMuon and specialized readouts DQ, L1T, L1T Layer 2, L1T Layer 3

• L1T time and vertex information from front end detector Read-Out Drivers (RODs) via the TTC

Outputs:

• 30-bit output from Logic 1 Block (Level 0) information to L2 Trigger

BGR07 Mask

The ATLAS Level-1 trigger mask database (BGR07) was provided that masks the first three bunches of each bunch crossing. This is designed to reduce the bunch-spacing dependence of the missing energy (RECO) trigger. The 3-bit mask is obtained from the shape of the Calorimeter trigger detector, upon which multiple bunches. Figure 10 shows this ATLAS BGR07 trigger that uses this bunch mask global. It can be seen the rate is reduced because the luminosity dependence is significantly calibrated.

Figure 11: L1TP trigger processing flowchart. The input to the L1TP is the first three bunch crossing. The output is the final Level-1 trigger decision. The pre-scaler (input) is 12.5 MHz and the output is 1.3 MHz.

Pre-Upgrade Plans

The L1TP has been operating at maximum capacity. Upgrade plans are prepared for the 2013 long shutdown of LHC, which will almost double the capacity of the L1TP to 300 MHz. This upgrade is necessary to cope with the increased number of interactions per crossing. The L1TP is designed to be increased to 300 MHz. This will be achieved in the mid-2014 upgrade as part of the 2013 L1T upgrade plan.

Figure 12: Phase of L1TP beam line compared with L1TP timing signal. The phase shifter is monitored by the TTCombat algorithm and set at the best delay between the latch for the clock to the detectors on the latch.

Figure 13: Outline of the L1TP hardware. The Cluster Address Memory supports up to 128 triggers, forming 2000 trigger masks for the multi-object trigger (see Section 5.3). This will allow the L1TP to use its full bandwidth.