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ATLAS Trigger Menus at Luminosity 10^{33} cm^{-2} s^{-1}

Version 2

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Abstract

Sample trigger menus are proposed for the ATLAS LVL1, LVL2, and LVL3 triggers for luminosity 10^{33} cm^{-2} s^{-1}. These trigger menus are based on ATLAS physics requirements. A catalog of physics processes studied by the ATLAS physics groups is included in an appendix, and trigger menu items for LVL1, LVL2, and LVL3 are proposed for each of these physics channels. The trigger rates indicated in the catalog and in the trigger menus are 'best guess' values. This note is an update of DAQ-NO-54. The sequential selection option for the LVL2 trigger has been explicitly implemented in this new version of the trigger menus.

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1. Introduction

The intention of this note is to propose full LVL1, LVL2, and LVL3 trigger menus for the ATLAS trigger for luminosity $L=10^{33}$ cm^{-2} s^{-1}. These trigger menus are based on a catalog of physics processes studied by the ATLAS physics groups. The present note is an update of the earlier DAQ-NO-54 [1]; the sequential processing option described in DAQ-NO-55 [2] is explicitly implemented in these new trigger menus.

Section 2 of this note presents the main sources for the physics catalog in the Appendix. Section 3 describes the fast simulation program used to calculate many of the trigger rates [3]. Section 4 describes in more detail the origin of the trigger rates for each trigger type and the single-particle efficiencies at LVL1, LVL2, and LVL3. Section 5 describes the trigger strategy implemented in the sample trigger menus presented here, including a description of the ten processing steps foreseen for the LVL2 trigger. Section 6 lists the sample LVL1, LVL2 and LVL3 trigger menus, as well as the input menus for the ten LVL2 processing steps and a breakdown of the LVL3 trigger menu into data streams for the major ATLAS physics objectives. Section 7 discusses alternative LVL2 and LVL3 trigger strategies and proposes a small number of strategies which could be consistent with the expected hardware and software performance of the global higher level (LVL2 plus LVL3) ATLAS trigger. The catalog of physics processes used to define the sample trigger menus is given in the Appendix.

2. Physics Processes

We have attempted to include in this note all the physics channels that have been analyzed by the ATLAS physics groups. The main references used for the original version of the catalog were the ATLAS Technical Proposal [4], the MSSM Higgs studies in PHYS-NO-74 [5], and the ATLAS SUSY Workshop [6]. Additional channels have been added for this second version of the physics catalog, mostly based on the LHCC SUSY Workshop of October 1996 [7].

In February 1998, after the first draft of the present note, a reunion was organized by the ATLAS Trigger Performance coordinator to discuss modifications to the ATLAS trigger menus [8]. Several modifications were made to this note in response to the recommendations received at that meeting:

- Prescaled lepton and jet triggers were added to cover the full E_t range, down to zero E_t.
- Inclusive missing-E_t triggers were replaced by missing-E_t plus leptons or jets.
- The threshold for di-electron triggers was reduced from 15 GeV to 10 GeV.
- SUSY triggers for specific SUSY points were combined into generic SUSY triggers.
- Specific triggers were included for stable SUSY particles with times-of-flight greater than one beam-crossing.

3. Trigger Simulations

3.1 Fast Simulations

The fast simulation program written by J. Bystricky (now called PATRIGS, for ‘Parameterized Trigger Simulations’) has been used in these trigger studies [3]. Dijets and other known physics processes are generated in several P_t bins using PYTHIA. Pile-up events are added, taking into account the pulse shape in the calorimeters. Beam-crossing identification (BCID) is included for each trigger tower, for ECAL and HCAL separately. Rates for each trigger algorithm are obtained by combining the individual rates in each of the P_t bins with appropriate weights. The rates are normalized correctly at low E_t, where some of the triggers come from the minimum-bias ‘pile-up’ events; the normalization procedure gives rates which increase smoothly to the beam-crossing limit of 40 MHz at zero E_t. Total rates at a given trigger level take into account the overlap between the different trigger items.

Bremsstrahlung and gamma conversions are included in the fast simulations. Longitudingal and transverse shower profiles are calculated. Tracking is included for regions within RoIs. Muon momentum smearing due to energy-loss fluctuations is also taken into account.

3.2 Notation

The notation for the analysis and trigger conditions follows the notation used in the Technical Proposal. Trigger objects at LVL1 are indicated by capital letters; those at LVL2 (and in the physics analysis) are indicated by small letters. Some examples are given in the following table:

Trigger object	E_t threshold	Conditions	LVL1 object	LVL2 object
$\mu^\pm$	6 GeV		MU6	mu6
$\mu^\pm$	6 GeV	isolation	MU6I	mu6I
EM cluster	80 GeV		EM80	em80
γ	15 GeV	isolation		g15I
$e^\pm$	20 GeV	isolation		e20I
$\tau^\pm$	80 GeV		TAU80	tau80
$h^\pm$	80 GeV	isolation		h80I
jet	100 GeV		J100	j100
jet	30 GeV	B-jet tag		b30
missing-E_t	100 GeV		ME100	me100
scalar-E_t	1000 GeV		SE1000	se1000
total-E_t	1000 GeV		TE1000	te1000
track from full scan	5 GeV		T5	t5
$e^\pm$ from full scan	1 GeV	TR signal	E1	e1

The scalar-E_t is the scalar sum of the E_t in each tower. The total-E_t is the sum of the missing-E_t and the scalar-E_t. The LVL2 versions of the missing-E_t, scalar-E_t and total-E_t are first corrected for the E_t of any muons found in the event (ME100c is the corrected version of ME100), then recalculated, if necessary, using the full calorimeter dynamic range and the energy-dependent calibration (me100 is the recalculated version of ME100c).

The subscript 'β' on $e^{\pm}$ triggers ($e20I_{\beta}$) indicates that most of the hard bremsstrahlung has been rejected to obtain higher quality $e^{\pm}$ candidates at a lower rate.

For B-physics triggers, the full TRT tracking volume is searched for tracks above 1 GeV; new RoIs are created for each of these 'tracks from full scan'. The symbols 'T5' and 'E1' refer to track parameters from the TRT full scan; the electron identification (E1) requires a TR signal in the TRT. The symbols 't5' and 'e1' are used after confirmation of the tracks in the SCT. Higher-P_t tracks (t5) can be identified as muons (mu5) or electrons (e5) using LVL2 muon and calorimeter algorithms.The symbol 'tt15' used in the B-physics menu items indicates that the combined E_t of the tracks must exceed 15 GeV/c. Mass cuts and transverse mass cuts to select particle 'X' are denoted M(X) and M_T(X) respectively. The symbol NN(bbH) in the Event Filter data streams (LVL3F) indicates that neural nets are foreseen to preselect events for the analysis of the channel bbH -> bb bb.

4. Trigger Rates

The trigger rates indicated in this note are 'best guess' estimates, based on as much information as is available. The LVL1 trigger rates and the LVL1 rates for non-trigger RoIs are taken from the fast simulations described above [3]. The higher-level trigger rates, including the LVL3 rates, are obtained using rejection factors obtained from individual studies performed for the muon, calorimeter, and inner detector TDRs. Where necessary, backup documents written for the Technical Proposal are used. Real physics channels have been taken into account where possible, so that rates are not reduced below known physics channels such as top production or leptonic decays of W's and Z's.

4.1 Muon Triggers

The single muon trigger rates and dimuon trigger rates are taken from the Technical Proposal backup documents [9], [10], [11], from the Muon Spectrometer TDR [12], and from recent work on background from π/K decays [13]. All of these muon trigger rates are dominated by physics sources from the interaction zone. The LVL1 rate for low-P_t muons has been increased from the Technical Proposal value of 8 kHz to about 20 kHz to take into account the higher values found for π/K backgrounds [13]. The efficiency for the LVL1 muon trigger is 88% at the nominal P_t threshold (6 GeV) in the barrel region (including 95% geometrical acceptance) and 72% in the endcap region (including 90% geometrical acceptance) [12].

Furthermore, the muon trigger acceptance is limited to $|\eta| < 2.4$, whereas the inner tracker covers out to $|\eta| < 2.5$ and the precision muon chambers out to $|\eta| < 2.7$. For multi-lepton events, some of the efficiency loss can be recovered after the TRT full scan by identifying muons that were missed by the LVL1 trigger.

Three algorithms are used at LVL2 to reduce the background for the muon triggers. The stand-alone muon algorithm uses the precision muon chambers (MDTs) to improve the quality of the tracks and the sharpness of the P_t cuts. The track-match to the inner detector once again improves the Pt resolution and removes tracks which originate far from the beam axis. Finally, calorimeter isolation cuts can be used to select isolated muons from W decays and from new physics such as Higgs and SUSY decays.

In the fast simulations of the muon triggers, the effective P_t threshold is adjusted to give the LVL1 trigger rates calculated by the muon group. At LVL2, the tracking in the inner detector eliminates most of the muons from K decays and some of the muons from π decays. Isolation cuts based on calorimeter data are assumed to give a rejection of a factor 10 against muons in non-b jets. Recent studies have shown that the factor 10 is obtained for b-jets only for muons above 40 GeV [14]; we assume a rejection factor of 1.5, 2.0, 2.5, 4.0, and 10, for b-jets with muons above P_t = 6, 10, 15, 20, and 40 GeV, respectively.

The LVL2 efficiency is supposed to be about 95% of the LVL1 efficiency. No further cuts are applied to the muons at LVL3, even though some improvements could be made in the corrections for the energy loss in the calorimeter and in the rejection of π decays.

4.2 B-Physics Triggers

B-physics triggers in ATLAS are depend on the presence of a low-P_t muon at LVL1. The B-physics trigger rates used here are based on recent work by M. Smizanska [15], [16]. The LVL2 trigger sequence starts with the confirmation of the trigger muon in the precision muon chambers and in the inner tracker. A search is then performed for tracks in the full TRT tracking volume (full scan). Tracks found in the TRT full scan are analyzed in the SCT only if their space information is needed for mass calculations or in order to locate the track in the calorimeter or muon detectors. The higher-P_t tracks are analyzed in the calorimeter and muon systems in order to identify electron and muon candidates. The secondary vertex tag for the B-physics candidates differs from the b-jet vertex tag in that only those tracks identified as tracks from the B decay are considered for the secondary vertex. Identification of these secondary B vertices is included in the LVL3 trigger menu, but the algorithm was not used in the present version of the LVL2 trigger menus.

Nonetheless, the interesting B physics that could be studied at ATLAS is nearly unlimited (roughly 1 MHz at low luminosity). ATLAS physicists should be encouraged to explore as many interesting physics channels as possible. The battle for available trigger bandwidth will be fought when the first beam arrives. For now, we have selected a 'toy' menu of major B-physics trigger items designed to fit into the presently allocated bandwidth without using the B vertex reconstruction.

4.3 EM Clusters and Tau Jets

The rates quoted here for LVL1 electron, gamma, and tau triggers are based on fast simulations [3]. Hadrons from tau decays do not suffer degradation by bremsstrahlung energy loss. Therefore, selection criteria have been chosen to give single-particle efficiencies of about 95% after LVL1 and 90% after LVL2 for isolated hadrons and taus, as well as isolated photons, at the nominal thresholds. For the electron triggers, the signals are affected by bremsstrahlung, so the single-particle efficiencies have been set to 90% after LVL1 and 85% after LVL2. The electron efficiency would be about 80% after the LVL3 bremsstrahlung recovery procedure.

The LVL1 electron/gamma and tau triggers are both based on ECAL and HCAL signals in 4×4 trigger towers. Electron/gamma and tau RoIs will be combined into a single RoI wherever possible by the LVL1 RoI hardware; this will avoid transferring the same data twice for RoIs passing both electron/gamma and tau hypotheses [17].

The LVL1 decision depends on cluster energy and on ECAL and HCAL isolation criteria. The tau trigger depends mainly on electromagnetic isolation, whereas the electron/gamma trigger rate is highly sensitive to hadronic isolation cuts. The rejection power of the isolation cuts depends on the choice of the isolation windows and on the BCID efficiency for small pulses [18]. (The calorimeter energy sums for the LVL1 trigger have a least count of 1 GeV.)

The LVL1 rates also depend on the calibration technique assumed. The EM calorimeter is calibrated using the energy deposited by single electrons. The fast simulations quoted here use the energy deposited in 25 trigger towers [3]. The electron trigger rates in the LVL1 TDR are somewhat lower than the fast simulation rates used here, because the 2-tower trigger sums were used directly for the calibration for the LVL1 TDR [19].

The LVL2 algorithms for electron/gamma and hadron/tau triggers use the full calorimeter granularity and the full dynamic range of the signals. The selection criteria include cluster shapes in the EM calorimeter as well as tighter Et cuts and refined isolation criteria. The rejection factors estimated for the LVL2 calorimeter algorithms are given at the end of the next subsection.

4.4 Tracks in the Inner Detector

Electron and tau trigger algorithms require matching tracks in the inner detector. These algorithms are performed at LVL2, because the inner detector data is not available at LVL1. LVL2 rejection factors used here are based on the Inner Detector TDR [20]. When necessary, further details are taken from work presented in the Technical Proposal backup documents using the old ATLAS geometry [21], [22], [23].

Track algorithms for the tau triggers are based on the track resolution given in the ID TDR [20], except that the pointing error was assumed to be 2 times worse at LVL2 than in the off-line reconstruction. The uncertainty in $1/P_t$ using the full inner detector (pixels + SCT + TRT) can be given approximately by the following formula (in units of TeV^{-1}):

$$\sigma(1/P_t) = 0.4 + (20\ GeV)/P_t$$

For the fast simulations, the resolution at LVL2 is assumed to have a pointing error 2 times worse than the off-line code, so the corresponding uncertainty in $1/P_t$ is given by the following formula (in units of TeV^{-1}):

$$\sigma(1/P_t) = 0.4 + (40\ GeV)/P_t$$

The track-match in the inner detector requires one or more tracks with parameters matching, within errors, the E_t, η, and ϕ measured in the calorimeter. The single-hadron selection criteria require a single track with $P_t + 2\sigma(P_t) > E_t$; these cuts select single-hadron tau decays (branching ratio 12%). The more general track-match criteria for tau candidates accept either 1 or 3 charged tracks with $\sum P_t + 2\sigma(P_t) > E_t$ (branching ratio 22%).

Electron trigger rates are quoted in the ID TDR using the precision silicon tracker (SCT + pixels) alone, using the TRT alone, or combining the silicon tracker and the TRT. The match between the calorimeter and the tracker was required to satisfy $E_t/P_t < 4$ for the SCT and $E_t/P_t < 5$ for the TRT. For single electrons with $P_t = 20$ GeV at low luminosity (no pile-up added), the rate and the tracking efficiency depend on which tracking systems are used, as shown below:

Silicon tracker alone	$\varepsilon = 93.2\%$	trigger rate = 0.4 kHz	symbol ‘e20I’
TRT alone	$\varepsilon = 90.1\%$	trigger rate = 0.7 kHz	*not used*
Silicon tracker + TRT	$\varepsilon = 86.1\%$	trigger rate = 0.3 kHz	*not used*
Silicon tracker + TRT	$\varepsilon \approx 70\ \%$	trigger rate = 0.15 kHz	symbol ‘$e20I_\beta$’

The first three entries are taken from the Inner Detector TDR [20]. The fourth entry is an estimate of the trigger rate and tracking efficiency that can be obtained if most of the events with hard bremsstrahlung are rejected. Only the results using the silicon tracker alone give a total electron efficiency after LVL2 consistent with our 85% requirement.* For this reason, the silicon-only results are used here for most of the LVL2 electron trigger items (‘e20I’). For certain high-rate trigger items, such as W -> e ν events for the W mass measurement, the

* The loss of efficiency associated with the use of the TRT at LVL2 confirms earlier results obtained with the old geometry [24].

higher-quality, lower-rate electron candidates obtained after bremsstrahlung rejection are used ('e20I$_\beta$').

The LVL2 input menus, which correspond to individual LVL2 processing steps, are described in Section 5.4 of this note. For the EM clusters and for taus, trigger RoIs are processed first in the calorimeter subsystem, and then in the inner trackers. The rejection factors (with respect to LVL1) used here for EM clusters, single hadrons, and taus, are given in the following table:

REJECTION FACTORS W.R.T. LVL1 TRIGGER

Trigger item	CALO	TRACK	TOTAL
EM80	2	15	30
EM40I	10	10	100
EM20I	5	5	25
EM15I	3	4	12
EM10I	2	3	6
H150	1.25	40	50
H80I	2	30	60
H40I	2	20	40
H20I	2	10	20
TAU150	1.25	12	15
TAU80I	2	9	18
TAU40I	2	6	12
TAU30I	2	4.5	9
TAU20I	2	3	6

The LVL3 electron triggers should take into account the bremsstrahlung fit results given in the Inner Detector TDR [20].

4.5 Jet Triggers

The jet trigger rates are calculated using the fast simulation program, including pile-up, pulse shapes, and BCID [3]. The 1 GeV least count in the LVL1 energy sums has been taken into account in calculating the LVL1 trigger rates. The effective LVL1 thresholds are set to ensure 95% efficiency at LVL2 for energy clusters above the nominal threshold. The LVL2 rates are lower than the LVL1 rates because of the difference in the jet energy scales. The LVL3 jet rates are taken to be equal to the LVL2 rates, although some improvement is possible due to improved gap corrections and corrections for multiple interactions and overlapping jets.

The efficiency is poor at LVL1 for jets with E_t below 20-30 GeV. Therefore, the LVL1 trigger menu and the LVL1 RoI flags are limited to 30 GeV in this note. These low-E_t jets can be recovered at LVL2 for a certain number of events (≤ 1 kHz) by performing a ‘full jet scan’ using the calorimeter energy sums in each trigger tower. This is the same data (ΣE_x, ΣE_y) as that required for the missing-E_t recalculation. The execution time of the full jet scan algorithm is estimated to be about 1 ms.

4.6 B-jet Vertex Tags

B-jet vertex tags are included in the LVL2 trigger menu in accordance with the LVL2 URD [25]. The LVL2 b-jet tag requirement is only ‘desirable’, so that less ambitious LVL2 triggers will be required if we fail to develop a successful algorithm*. In DAQ-NO-54 [1], we assumed that the b-jet tag gave a rejection for non-b jets by a factor 10 at LVL2 for low luminosity, compared to the factor 100 quoted in the Technical Proposal (Section 11.3.1), for 50% efficiency for b jets with an E_t of 15 GeV. In the present version of the trigger menus, we assume rejection factors at LVL3 which are a factor two worse than those quoted in the Inner Detector TDR [20] for b-tag efficiencies of 53% (R = 20 for P_t = 15 GeV) and 64% (R = 20, 40, and 60 for P_t = 40, 50, and 100 GeV, respectively). At LVL2, we assume the rejection is lower by factor four. The rejection factors assumed at LVL2 and LVL3 are shown below, together with the rejection found in the off-line reconstruction [26]:

B-jet P_T	Efficiency	LVL2 RJT	LVL3 RJT	Off-line
15 GeV	50%	5	10	20
30 GeV	55%	5	10	20
40 GeV	60%	5	10	20
50 GeV	60%	10	20	40
80 GeV	60%	12.5	25	50
100 GeV	60%	15	30	60
150 GeV	60%	15	30	60

Results similar to our assumptions have been obtained recently using a b-jet vertex tag based on pixel data (see section 5.4 below) [27]. The execution time is about 1 ms when only pixel data are used [28]. The non-b jet rejection at LVL2 is three to four times worse than the rejection obtained off-line [27]. This is consistent with the assumptions listed above. The assumptions

* Soft-lepton tags cannot be used to improve the quality of the b-jet event sample for the final off-line analysis of H -> b b candidates. The analysis presented in Section 6.7.8 of the Inner Detector TDR is overly ‘optimistic’; the b-jet efficiency was increased when the soft-lepton tags were added to the vertex tags, but the efficiencies for non-b jets were left unchanged [20]. Using the numbers given in Section 6.2.2 of the ID TDR, we can estimate that the efficiency for c jets increases from 14.9% to about 22% when the soft-lepton tags are added, and the efficiency for jets without heavy quarks increases from 1.1% to about 3%. Correcting the background rates, we find that the signal-to-background ratio (S/B) is reduced from 1.8% to about 1% when the soft-lepton tags are added; $S/\sqrt{B}$ is reduced from 2.43 to about 2.0. Note that leptons from gluon splitting to heavy flavors were removed from the background samples both in Section 6.7.8 and in Section 6.2.2, ‘for consistency’.

are conservative, because SCT data can be used at LVL2 to improve the initial pixel-only rejection.

4.7 Missing-E_t Triggers

The missing-E_t triggers, like the jet triggers, are calculated from fast simulations and include the influence of pile-up, pulse shape, and BCID [3], [29]. The main LVL1 missing-E_t triggers contain leptons or jets as well as the missing-E_t. Inclusive missing-E_t and scalar-E_t triggers have also been included; their thresholds can be adjusted to keep the trigger rates as low as desired. Some of the LVL2 and LVL3 trigger rates which combine missing-E_t with other trigger objects are based on the missing-E_t resolution shown by Cavalli, et al, in PHYS-NO-51 [30] . We assume a missing-E_t resolution corresponding to a total E_t which is twice the sum of the E_t thresholds for the other trigger objects. Furthermore, we assume, conservatively, that the missing-E_t resolution for the LVL2 trigger is about twice the ultimate resolution shown by Cavalli, et al., and the resolution at LVL3 is $\sqrt{2}$ times the ultimate resolution.

The missing-E_t and scalar-E_t trigger thresholds are quoted at the nominal threshold values at each trigger level. The efficiency at that trigger level is therefore about 50%. The nominal trigger thresholds are increased at each trigger level, so the 50% efficiency at the nominal trigger threshold should be maintained.

4.8 Mixed Triggers and Combined Trigger Rates

The fast simulation program gives rates for mixed triggers such as triggers containing both muons and electrons, jets and leptons, or missing-E_t and jets or leptons. It also gives combined trigger rates for full trigger menus, correcting automatically for overlapping triggers [3].

One example of a mixed trigger is the LVL1 item requiring a 30 GeV isolated tau plus a 15 GeV isolated EM cluster. The LVL1 processors distinguish overlapping trigger items of the same type, but they do not distinguish overlapping items of different types. Therefore, the trigger conditions must require the presence of two objects with the smallest common selection criteria; in this case, two 15 GeV isolated taus. Events with a 30 GeV isolated EM cluster and a 15 GeV isolated tau will also pass these criteria, but they are already accepted by the single isolated EM cluster trigger item in our LVL1 menu. The ratio of two between the P_t thresholds for the hadronic tau jet and the electronic tau decay was based on a recent study by I. Hinchliffe [26].

4.9 Detector Monitoring and Calibration

Physics channels required for detector monitoring have been included in the physics catalog in the Appendix. All identified leptons - electrons and muons - will serve as monitors for the

EM calorimeter, the muon chambers, and the inner detector. Leptonic decays of the Z^0 will also be used. Jets recoiling from Z^0 decays can be used as one monitor for the hadron calorimeter. Leptonic decays of $W^{\pm}$ can be used to monitor the missing-E_t calculations. All events accepted at LVL3 can be used to monitor the beam position. Calibration and alignment corrections should be calculated in the LVL3/EF processors. The latest calibration constants will be made available to all 3 trigger levels. The prescaled triggers, including the prescaled beam crossing, will also be used for monitoring.

5. Trigger Strategy

5.1 Requirements and Constraints

The trigger menus presented here are based on the rate requirements in the ATLAS Technical Proposal [4]. The LVL1 trigger is limited to 75 kHz in the latest CORE costing. It should be ‘upgradeable’ to 100 kHz. The design output rate for the LVL2 trigger is 1 kHz. The design output rate for the LVL3 trigger (the Event Filter) is 100 MB/s, or 100 Hz of full events.

The trigger menus in the present note attempt to maintain a safety factor with respect to the requirements in the Technical Proposal. The LVL1 rate is limited to 40-50 kHz, and the LVL2 rate is limited to about 500 Hz; these design values provide a safety factor of about two with respect to the rate limits in the Technical Proposal. Data storage is not a serious problem, so the LVL3 rate does not have to be maintained within the design limit. Nevertheless, the number of events in the event streams intended for full analysis should be kept within the 100 Hz limit, unless the available processing power is increased. The effect of possible improvements in the projected hardware performance is discussed in Section 7 of this note.

5.2 Sequential LVL2 Selection

The trigger menus presented here are based on a sequential event selection strategy. Some of the trigger algorithms proposed for LVL2 can only be performed on a small fraction of the events accepted at LVL1. At the time of the Technical Proposal, the B-physics algorithms had already been identified as requiring sequential processing: tracks found in the full TRT scan would create new RoIs that would then be processed through the silicon (including pixel), calorimeter, and muon subsystems. More recently, missing-E_t recalculation and b-jet vertex tags have been incorporated in the LVL2 trigger menus; these algorithms must be run on preselected event samples because they require a large number of data transfers (missing-E_t) or a large amount of computing power (b-jet tags).

The LVL2 strategy described in this note consists of 3 sequences with a total of 10 processing steps. The three sequences are the confirmation of the trigger RoIs, the processing of B-physics candidates, and the processing of high-P_t candidates. The B-physics algorithms are run first so that muon candidates missed at LVL1 because of the geometrical acceptance can be used at LVL2 for the selection of high-P_t physics channels.

The confirmation of the trigger RoIs consists of 2 processing steps: First stand-alone muon and calorimeter algorithms are used to confirm and refine the LVL1 trigger conditions. Then the inner detector is used to find tracks with parameters matching those found in the muon or calorimeter. The missing-E_t and scalar-E_t values from LVL1 are corrected at this stage to take account of the contribution from trigger muons.

The second LVL2 sequence consists of 4 processing steps needed for the identification of B-physics candidates. The search for B-physics candidates is limited to events with a confirmed low-P_t muon trigger. The processing steps are the TRT full scan, confirmation of tracks in the precision tracker (SCT + pixels), particle identification in the calorimeter and muon subsystems, and reconstruction of B vertices. The full scan looks for all tracks with $P_t > 1$ GeV/c and identifies tracks with large TR signals as electron candidates. Only tracks required for the identification of specific B-physics hypotheses are confirmed in the silicon system and identified as electrons or muons.

The final LVL2 sequence, before the global LVL2 decision, consists of 4 processing steps for high-P_t candidates. Non-trigger RoIs flagged at LVL1 are processed, first in the calorimeter subsystem, then, except for the jet RoIs, in the inner trackers. The final steps are the b-jet vertex tag and the missing-E_t calculation. The vertex tag uses pixel and SCT data in the b-jet RoI and requires roughly 250 ms on a 500 MIPS machine. The missing-E_t calculation uses E_t sums from all of the calorimeter towers and requires a great number of very small data transfers (assuming that the energy sums in each calorimeter tower have been performed upstream of the LVL2 processors).

5.3 Trigger Menus

The objective of this note is to present LVL1, LVL2, and LVL3 trigger menus for low-luminosity operation of the ATLAS detector. These trigger menus are chosen to meet the ATLAS physics requirements, while respecting the maximum design rates. A sequential LVL2 selection strategy is used to maximize the physics potential, while minimizing the trigger rates and the resources. Input menus are used to select those events and those RoIs which must be treated in each LVL2 processing step. The LVL2 input menus are labelled ‘LVL2_xy’, where ‘xy’ is a mneumonic for the particular processing step. The final LVL2 decision depends on the ‘full’ LVL2 menu (LVL2).

The LVL3 trigger menu (LVL3) includes all events which must be sent to permanent storage. Some of these event records could contain compressed or reduced data volumes. The LVL3 events include calibration events, events for physics analyses, and events for background studies. The largest volume of LVL3 data will probably be reserved for possible background studies. The reduced set of events destined for fast-track physics studies are flagged in a separate trigger menu (LVL3F).

5.4 Input Trigger Menus for LVL2

The sequential LVL2 trigger strategy described here implies the existence of further trigger menus for internal LVL2 use. The LVL2 trigger processing is divided into 10 sequential steps. The first two processing steps are used to confirm the trigger RoIs. The next four steps apply only to the low-Pt muon triggers; they correspond to the sequential B-physics algorithms. The final four processing steps complete the high-Pt trigger algorithms, using additional muons found in the TRT full scan to correct some of the geometrical losses for events with more than one muon. Each of the 10 processing steps requires transfer of data from certain subsystems to the LVL2 processors. The processing steps and the corresponding input trigger menus are described in detail below. The average data volumes required per RoI (or per event for the missing-Et algorithm) and the average execution time are given for each type of algorithm [31]. The data volumes assume that all ROB data is transferred to the processors if any of the data in the ROB is needed for the RoI; these data volumes could be reduced if we succeed in reading out only the data in the RoI [2]. The execution times are estimated for processing on a 500 MIPS LVL2 processor [2].

TRIGGER RoI CONFIRMATION

Symbol	Processing step	ROB data	Data volume	Execution time
LVL2_tr	Trigger RoI	MU or CA	6 kB	100 μs
LVL2_tt	Trigger track	PIX, SCT, TRT	4 kB	1,000 μs

B-PHYSICS PROCESSING STEPS

Symbol	Processing step	ROB data	Data volume	Execution time
LVL2_fs	Full Track Scan	TRT	140 kB	50,000 μs
LVL2_pz	New track P_z	PIX and SCT	1 kB	500 μs
LVL2_id	New track ID	MU and CA	12 kB	200 μs
LVL2_bv	B vertex tag	PIX and SCT	5 kB	10,000 μs

HIGH-Pt PROCESSING STEPS

Symbol	Processing step	ROB data	Data volume	Execution time
LVL2_nr	Non-trigger RoI	MU or CA	5 kB	100 μs
LVL2_nt	Non-trigger track	PIX, SCT, TRT	4 kB	1,000 μs
LVL2_et	Miss-E_t & jet scan	CA energy sums	16 kB	500 μs
LVL2_bv	B-jet vertex tag	PIX and SCT	5 kB	10,000 μs

The execution time for the b-jet vertex tag is based on a plausible extension of the stand-alone pixel-only version of the b-jet vertex tag described in the Pixel TDR [27]. This pixel version gives useful non-b-jet rejection with an execution time of only 1 ms [28]. The execution time has been increased to 10 ms on the assumption that certain tracks found in the pixel analysis will be refined using SCT data. The execution time for the 'et' triggers is an average of the 100 μs required for the missing-E_t calculation and about 1 ms required for the full jet scan.

5.5 Event Filter Data Streams

Event Filter data streams, which are now considered to be event tags rather than physical data streams, can be organized on several levels: Events can be tagged according to inclusive trigger objects or pairs of objects such as leptons, jets, or missing-E_t. The same events can be tagged for the presence of physics objects such as $W^{\pm}$, Z^0, or B. Specific B channels and specific discovery channels, such as Higgs decays or SUSY decays, can also be tagged. The Event Filter data streams in Section 6.8 of this note are tagged according to major ATLAS physics objectives - Higgs, SUSY, top, W, Z, vector boson pairs, heavy vector bosons, leptoquarks, and QCD. The tags can be used to distinguish 'good' physics candidates from the larger sample of events required for background studies.

5.6 'Golden' Events in the Event Filter

One of the tasks of the Event Filter is to identify candidates for 'fast-lane' discovery. Typical examples of these 'golden' events include Higgs decays to 4 leptons and Z' decays to very-high-energy di-leptons. SUSY decays to lepton or gamma pairs plus very-high missing-E_t (greater than 300 GeV) are further examples of 'golden' discovery channels.

Even more urgent than the 'fast-lane' discovery channels are the 'zoo' events - events so interesting that they should ring a bell in the counting house and require immediate attention. Recent studies of GMSB - the Gauge Mediated Symmetry Breaking version of SUSY - have provided fascinating examples of 'zoo' events in which a small number of events (roughly 5) would suffice to establish the GMSB mechanism. The characteristic signature of GMSB would be the presence of heavy, long-lived neutral (neutralino) or charged (stau) particles, which may or may not decay within the detector volume. (The decay products would be, respectively, a gamma plus a Gravitino or a tau lepton plus a Gravitino.) Some examples of possible GMSB 'zoo' events are the following:

- Trilepton SUSY events with delayed gamma emission from a neutralino, producing gammas which do not point to any visible vertex.
- Slow, ionizing stau particles, out of time, but visible in the TRT, associated with large missing-E_t.
- Stau pairs with one fast stau visible in the RPC producing a high-P_t muon trigger, and one slow stau, out of time and visible only in the MDT [32].

Note that ‘golden’ events and especially ‘zoo’ events could be analyzed on-line using an interactive reconstruction program such as ARVE.

6. Sample Trigger Menus

6.1 LVL1 Trigger Menu

This standard LVL1 trigger menu is very similar to the LVL1 trigger menu in the T.P. The isolated EM cluster (which has already been included in the trigger simulation studies) has been added. A τ trigger item has been added. The jet and missing-E_t thresholds have been reconsidered, and the corresponding trigger rates have increased significantly. The 100 GeV jet trigger item now corresponds to a LVL1 threshold which will give 90% efficiency for LVL2 (or off-line) jets with E_t = 100 GeV. The prescaled trigger rate has increased following discussions with ATLAS theorists [8]. The total LVL1 trigger rate has increased from the T.P. value of 23 kHz to the present value of about 50 kHz, well below the CORE costing limit of 75 kHz.

Some prescaled trigger items have been included explicitly in the revised LVL1 trigger menu. They are intended to allow the measurement of inclusive trigger rates down to the lowest thresholds [8]. Prescaled menu items will also constitute about 10% of the trigger rate at the higher trigger levels. The prescaled items have not been listed in the LVL2 and LVL3 trigger menus, but they will require algorithm sequences similar to the normal trigger items. Note that the largest prescale factor used in the LVL1 menu is 10^5. It has been pointed out that such large prescale factors require at least 16 bits in the prescaler, rather than the 8 bits currently foreseen in the LVL1 CTP [33].

The proposed LVL1 trigger menu for luminosity 10^{33} cm^{-2} s^{-1} is shown below:

LVL1 TRIGGER RATES		Prescale	Events
LVL1	MU6		23 000 Hz
LVL1	EM80		520 Hz
LVL1	EM20I		11 980 Hz
LVL1	EM15I	prescale / 10^2	490 Hz
LVL1	EM10I	prescale / 10^3	380 Hz
LVL1	EM5I	prescale / 10^4	850 Hz
LVL1	EM10I + EM10I		9 330 Hz
LVL1	TAU150		1 730 Hz
LVL1	TAU80I		2 530 Hz
LVL1	TAU30I + EM15I		2 800 Hz
LVL1	J100		2 290 Hz
LVL1	J40	prescale / 10^2	1 090 Hz
LVL1	J20	prescale / 10^4	460 Hz
LVL1	J80 + J80		1 660 Hz
LVL1	J50 + J50 + J50		1 310 Hz
LVL1	J40 + J40 + J40 + J40		560 Hz
LVL1	ME40 + J50		820 Hz
LVL1	ME40 + EM10I		650 Hz
LVL1	ME60		70 Hz
LVL1	SE700		20 Hz
LVL1	Beam crossing	prescale / 10^5	320 Hz

SUM of LVL1 triggers	62 860 Hz
TOTAL LVL1 RATE corrected for overlaps	52 500 Hz

The total LVL1 trigger rate without the prescaled trigger items (EM clusters, jets, and beam-crossings) is 49 kHz. The LVL1 rate can be brought down to the 40 kHz design limit by removing the prescaled triggers and the non-isolated EM clusters and taus (EM80 and TAU150), by raising the single-jet threshold (J100 -> J120), and by tightening the selection criteria for the isolated EM clusters (EM10I). Note that the TAU150 candidates are not completely contained in the J100 event sample because of the difference in the LVL1 trigger algorithms.

The largest contributions to the LVL1 trigger rate come from the following channels:

B physics	⇒	MU6	23 000 Hz
W -> e ν	⇒	EM20I	11 980 Hz
A^0 -> $\tau^+ \tau^-$	⇒	TAU30I + EM15I	2 800 Hz
gluino -> bino + b -> e e + b b	⇒	EM10I + EM10I	9 330 Hz
SUBTOTAL for four major contributions			47 110 Hz
SUBTOTAL corrected for overlaps			43 000 Hz

LVL1 trigger flags from the LVL1 CTP were required in the parallel FEX version of the LVL2 trigger to limit the number of events requiring processing of non-trigger RoIs. With sequential processing and with data flow controlled by the LVL2 processors, trigger flags from the LVL1 CTP are not strictly required. LVL1 must nonetheless flag all RoIs which might be required for the LVL2 processing. LVL3 would require additional non-trigger RoI flags from LVL1 if the LVL3 processing is to be guided by the results obtained at LVL1 and LVL2 (see Section 7). The thresholds for the trigger RoIs and the non-trigger RoIs required for LVL2 and LVL3 processing are given in the list below; the number of trigger thresholds for each trigger object is also given and compared to the maximum number allowed by the LVL1 hardware [34].

LVL1 REGIONS OF INTEREST (RoIs)

Trigger object	Thresholds (GeV)	Trigger RoI	All RoIs	Max Number
Low-p_T muon	6	1	1	3
High-p_T muon	20	0	1	3
EM cluster	5, 7, 10, 15, 20, 80	5	6	8
Tau	20, 30, 80, 150	3	4	8
Jet	20, 30, 40, 50, 80, 100	5	6	8
Missing-E_t	40, 60	2	2	8
Scalar-E_t	250, 700	1	2	4

The 7 GeV threshold for the EM clusters is required only for LVL3.

6.2 LVL2 Confirmation of Trigger RoIs

The input menus for the LVL2 trigger are derived from the LVL1 trigger menu. The first step in the LVL2 processing is the confirmation of the LVL1 trigger RoIs in the stand-alone muon and calorimeter systems (MU, CA). The input menu for this first LVL2 processing step is given below (ignoring the prescaled triggers for now):

INPUT RATES FOR TRIGGER ROI CONFIRMATION		Events	RoIs
LVL2_tr	MU6	23 000 Hz	23 100 Hz
LVL2_tr	EM80	520 Hz	600 Hz
LVL2_tr	EM20I	11 980 Hz	12 030 Hz
LVL2_tr	EM10I + EM10I	9 330 Hz	18 940 Hz
LVL2_tr	TAU150	1 730 Hz	2 070 Hz
LVL2_tr	TAU80I	2 530 Hz	2 600 Hz
LVL2_tr	TAU30I + EM15I	2 800 Hz	6 400 Hz
LVL2_tr	J100	2 290 Hz	3 030 Hz
LVL2_tr	J80 + J80	1 660 Hz	3 530 Hz
LVL2_tr	J50 + J50 + J50	1 310 Hz	4 170 Hz
LVL2_tr	J40 + J40 + J40 + J40	560 Hz	2 370 Hz
LVL2_tr	ME40 + J50	820 Hz	1 370 Hz
LVL2_tr	ME40 + EM10I	650 Hz	670 Hz
SUM of input rates for trigger RoIs		59 180 Hz	80 880 Hz
TOTAL INPUT RATES corrected for overlaps		49 200 Hz	76 700 Hz

The second step in the LVL2 processing identifies muons, electrons, and taus by looking for matching tracks in the inner tracker (TRT, SCT, including pixels) for muon, e/gamma, and tau RoIs. The input menu for this second LVL2 processing step is given below:

INPUT RATES FOR TRIGGER TRACKS		Events	RoIs
LVL2_tt	mu6	9 000 Hz	9 050 Hz
LVL2_tt	em80	320 Hz	340 Hz
LVL2_tt	em20I	2 500 Hz	2 510 Hz
LVL2_tt	em10I + em10I	2 420 Hz	4 875 Hz
LVL2_tt	tau150	1 420 Hz	1 530 Hz
LVL2_tt	tau80I	1 320 Hz	1 340 Hz
LVL2_tt	tau30I + em15I	600 Hz	1 270 Hz
LVL2_tt	ME40 + em10I	340 Hz	345 Hz
SUM of input rates for tracks in trigger RoIs		17 920 Hz	21 260 Hz
TOTAL INPUT RATES corrected for overlaps		17 300 Hz	20 500 Hz

Note that the input trigger objects indicated in the above trigger menu (e.g. 'mu6') have been confirmed only in the muon and calorimeter subsystems; the confirmation of these objects in the inner tracker is performed in the present step (LVL2_tt).

6.3 LVL2 Processing Steps for B-physics Triggers

For the B-physics candidates, processing of non-trigger RoIs is replaced by the full scan of the TRT tracking volume. The input menu for the full TRT scan is given below:

B-PHYSICS : INPUT RATE FOR FULL SCAN IN TRT		Events
LVL2_fs	mu6	6 000 Hz
TOTAL RATE FOR FULL TRT SCAN		6 000 Hz

The next step in the processing of B-physics candidates is the determination of the full track parameters for tracks found in the full TRT scan using the SCT and pixel data. There are an average of about 20 new RoIs (tracks) per event. Not all of these RoIs need further processing, however. Spatial parameters must be calculated using the SCT data only if the track is needed for a mass calculation or for electron or muon identification (about 20% of the new RoIs). Calorimeter and muon algorithms are required only for the higher-P_t tracks. The trigger muon is not counted as one of the 'new' RoIs. The number of RoIs listed includes all tracks found in the full scan that satisfy the selection criteria indicated. The input rates for this algorithm are given below:

B-PHYSICS : INPUT RATES, TRACKS IN NEW RoIs		Events	RoIs
LVL2_pz	mu6 + T5	3 600 Hz	8 000 Hz
LVL2_pz	mu6 + T5 + T3	3 000 Hz	12 000 Hz
LVL2_pz	mu6 + E1 + E1	1 600 Hz	4 800 Hz
LVL2_pz	mu6 + 3 * T1.5 + $M_T(\phi)$ + $M_T(D)$	3 500 Hz	21 000 Hz
SUMS of input rates for tracks in new RoIs		11 700 Hz	45 800 Hz
TOTAL INPUT RATES corrected for overlapping triggers		6 000 Hz	35 000 Hz

In the next processing step for the B-physics triggers, electron candidates and tracks with P_t > 5 GeV must be identified as muons, electrons or hadrons using the muon and calorimeter data. The input rates for these algorithms are given below:

B-PHYSICS : INPUT RATES FOR NEW TRACK ID		Events	RoIs
LVL2_id	mu6 + e1 + e1 + M(ee) > 2 GeV	260 Hz	650 Hz
LVL2_id	mu6 + t5	3 000 Hz	6 000 Hz
SUMS of input rates for track identification		3 260 Hz	6 650 Hz
TOTAL INPUT RATES corrected for overlap		3 130 Hz	6 500 Hz

B-physics trigger rates can be reduced by requiring that the tracks matching the trigger conditions come from a single displaced vertex. This algorithm is not used at LVL2 in the present trigger menus (the input rate to this algorithm is null). The algorithm is used at LVL3, however.

B-PHYSICS : INPUT RATES TO B VERTEX ALGORITHM			
LVL2_bv	*no entries*	0 Hz	0 Hz

6.4 LVL2 Processing Steps for High-P_t Triggers

The ‘extended’ LVL2 trigger menu is obtained after processing of the non-trigger RoIs flagged at LVL1, first in the stand-alone muon and calorimeter systems, then in the inner tracker. The non-trigger RoIs to be processed in the stand-alone systems (MU, CA) are given in the following list, where the event rates are given in the next-to-last column, and the non-trigger RoI rates are given in the last column.

INPUT RATES FOR NON-TRIGGER ROIs		Events	RoIs
LVL2_nr	mu6 + EM10I	800 Hz	860 Hz
LVL2_nr	e20I + EM10I	90 Hz	125 Hz
LVL2_nr	j100 + EM10I	200 Hz	590 Hz
LVL2_nr	j50 + j50 + j50 + EM10I	120 Hz	350 Hz
LVL2_nr	mu15 + TAU20I	80 Hz	120 Hz
LVL2_nr	mu20 + J30	80 Hz	140 Hz
LVL2_nr	mu15I + J30	40 Hz	70 Hz
LVL2_nr	e20I + J30	160 Hz	280 Hz
LVL2_nr	j100 + J30 + J30	1 020 Hz	3 000 Hz
LVL2_nr	j80 + j80 + J30	570 Hz	1 140 Hz
SUMS of input rates for events with non-trigger RoIs		3 160 Hz	6 675 Hz
TOTAL INPUT RATES corrected for overlapping triggers		2 900 Hz	6 000 Hz

The largest contributions to the non-trigger RoIs comes from the following channels:

b b H^0 -> b b + b b	⇒	j100 + 2*J30	3 000 Hz of RoIs
b b H^0 -> b b + b b	⇒	2*j80 + J30	1 140 Hz of RoIs

Note that in the sequential selection option considered here, non-trigger RoIs are processed for less than 10% of the LVL1 events.

The next step in the LVL2 processing of the high-P_t triggers performs the track match to the inner tracker. The input rates for these algorithms are given below:

INPUT RATES FOR NON-TRIGGER TRACKS		Events	RoIs
LVL2_nt	mu6 + em10I	400 Hz	430 Hz
LVL2_nt	e20I + em10I	55 Hz	64 Hz
LVL2_nt	j100 + em10I	175 Hz	300 Hz
LVL2_nt	j50 + j50 + j50 + em10I	60 Hz	180 Hz
LVL2_nt	mu15 + tau20I	40 Hz	60 Hz
SUMS of input rates for events with non-trigger tracks		730 Hz	1 034 Hz
TOTAL INPUT RATES corrected for overlapping triggers		670 Hz	950 Hz

In the input menu above, ‘tau40I’ refers to the tau candidate after LVL2 confirmation in the calorimeter, but before checking for one or three matching tracks in the inner tracker.

The full LVL2 trigger menu includes missing-E_t recalculation and b-jet vertex tags, in addition to the extended trigger menu. Recalculation of the missing-E_t at LVL2 requires data from all of the calorimeter towers. The same data (LVL2 E_x and E_y sums for each calorimeter tower) can be used for the full jet scan, which is needed to find jets that were missed at LVL1 (jets with E_t less than about 30 GeV). The input event rates for the LVL2 missing-E_t calculation and full jet scan are given below:

INPUT RATES FOR MISSING-E_T CALCULATION		Events
LVL2_et	e80	20 Hz
LVL2_et	g40I	80 Hz
LVL2_et	e20I	400 Hz
LVL2_et	tau150	130 Hz
LVL2_et	tau30I + e15I	30 Hz
LVL2_et	j150 + j150 + SE250c	90 Hz
LVL2_et	j100 + j100	450 Hz
LVL2_et	j50 + j50 + j50 + j50	120 Hz
LVL2_et	ME40 + j50	490 Hz
LVL2_et	ME60	70 Hz
LVL2_et	SE700	20 Hz
SUM of input rates for missing-E_t calculation		1 900 Hz
SUBTOTAL corrected for overlapping triggers		1 600 Hz

INPUT RATES FOR FULL JET SCAN

LVL2_et	e20I	400 Hz
LVL2_et	e10I + e10I	280 Hz
LVL2_et	j150	300 Hz
SUM of input rates for missing-E_t calculation		980 Hz
SUBTOTAL corrected for overlapping triggers		900 Hz
TOTAL INPUT RATE corrected for overlapping triggers		1 900 Hz

The largest contributions to the missing-E_t recalculation come from the following channels:

W -> e ν	⇒	e20I	400 Hz
SUSY -> multijets + missing-E_t	⇒	2*j100	450 Hz
SUSY -> multijets + missing-E_t	⇒	ME40 + j50	490 Hz

The contributions to the full jet scan come from the following channels:

R-violating SUSY -> e + 8 jets	⇒	e20I	400 Hz
gluino -> bino + b -> e e + b b	⇒	e10I + e10I	280 Hz
b b H -> b b + b b	⇒	j150	300 Hz

One of the main purposes of the full jet scan was to find low-E_t b-jets. All of the 15 GeV jets listed below were found in the LVL2 full jet scan. The full list of RoIs to be processed at LVL2 for the b-jet vertex tags are listed below:

INPUT RATES TO B-JET VERTEX TAGS		Events	RoIs
LVL2_bv	mu20 + j30 + j30	20 Hz	60 Hz
LVL2_bv	mu15I + j30	30 Hz	50 Hz
LVL2_bv	e20I + j30	120 Hz	200 Hz
LVL2_bv	e10I + e10I + j15 + j15	200 Hz	1 000 Hz
LVL2_bv	j300	15 Hz	20 Hz
LVL2_bv	j150 + j15 + j15	270 Hz	400 Hz
LVL2_bv	j100 + j30 + j30	930 Hz	1 130 Hz
LVL2_bv	j80 + j80 + j30	570 Hz	650 Hz
LVL2_bv	j50 + j50 + j50	830 Hz	2 710 Hz
LVL2_bv	j40 + j40 + j40 + j40	320 Hz	1 380 Hz
SUMS of input rates for b-jet vertex tag		3 305 Hz	7 600 Hz
TOTAL INPUT RATES corrected for overlap		3 000 Hz	7 000 Hz

The b-jet tags for the heterogeneous 3-jet events are treated in two steps; the low-E_t jets are processed only if the high-E_t b-jet tag is successful. The largest contributions to the b-jet vertex tag algorithm come from the following channels:

gluino -> bino + b -> e e + b b	⇒	2*e10I + 2*j15	1 000 Hz of RoIs
b b H^0 -> b b + b b	⇒	j100 + 2*j30	1 130 Hz of RoIs
H^0 -> h^0 h^0 -> b b + b b	⇒	3*j50	2 710 Hz of RoIs
H^0 -> h^0 h^0 -> b b + b b	⇒	4*j40	1 380 Hz of RoIs
SUM of five major contributions			6 220 Hz of RoIs
SUBTOTAL for five major contributions			5 700 Hz of RoIs

6.5 LVL2 Trigger Menu

The full LVL2 trigger menu for luminosity 10^{33} cm^{-2} s^{-1} is shown in the following table:

LVL2 B-PHYSICS TRIGGERS		Events
LVL2	mu6 + e1 + e1 + M(J/ψ)	50 Hz
LVL2	mu6 + mu5 + mu3 + M(J/ψ)	20 Hz
LVL2	mu6 + e5 + mu3 + M(J/ψ)	10 Hz
LVL2	mu6 + t5 + t5 + M(B)	80 Hz
LVL2	mu6 + t1.5 + t1.5 + t1.5 + M(ϕ^0) + M(D_s)	100 Hz
LVL2	mu6 + mu5 + M(B)	50 Hz
SUM of all LVL2 B-physics triggers		310 Hz
SUM corrected for overlapping triggers		300 Hz

LVL2 HIGH-PT TRIGGER MENU		Events
LVL2	mu60	2 Hz
LVL2	mu20 + b30 + b30	6 Hz
LVL2	mu20I	40 Hz
LVL2	mu15I + b30	12 Hz
LVL2	mu15I + tau20I	3 Hz
LVL2	mu15 + g20I	1 Hz
LVL2	mu15I + mu6	1 Hz
LVL2	mu10 + mu10	13 Hz
LVL2	mu10I + j100	8 Hz
LVL2	mu10I + j40 + j40 + j40	1 Hz
LVL2	mu10I + g15I	4 Hz
LVL2	mu10I + e10I	8 Hz
LVL2	mu6 + e10I + e10I	1 Hz

LVL2	mu6 + mu6 + e10I		1 Hz
LVL2	mu6 + mu6 + mu6		1 Hz
LVL2	mu6I + j100 + j100		10 Hz
LVL2	mu6I + e15I		8 Hz
LVL2	mu6I + mu6I		9 Hz
LVL2	e100		10 Hz
LVL2	e80 + j100		7 Hz
LVL2	e80 + me40		2 Hz
LVL2	e80 + e80		1 Hz
LVL2	g80I		3 Hz
LVL2	e40I		7 Hz
LVL2	g40I + me40		4 Hz
LVL2	e20I + tau40I		4 Hz
LVL2	e20I + j40 + j40		6 Hz
LVL2	e20I + b30 + b30		3 Hz
LVL2	e20I + j15 + j15 + j15 + j15 + j15 + j15		12 Hz
LVL2	$e20I_{\beta}$ + b30		10 Hz
LVL2	$e20I_{\beta}$ + me20		50 Hz
LVL2	g20I + g20I		2 Hz
LVL2	e20I + e10I		2 Hz
LVL2	e15I + j100		8 Hz
LVL2	e15I + g15I		12 Hz
LVL2	e15I + e15I		4 Hz
LVL2	$e10I_{\beta}$ + $e10I_{\beta}$ + b15 + b15		10 Hz
LVL2	e10I + e10I + e10I		1 Hz
LVL2	tau200I		5 Hz
LVL2	tau150 + me80		1 Hz
LVL2	tau80I + tau80I		1 Hz
LVL2	tau30I + $e15I_{\beta}$ + me20		12 Hz
LVL2	j500		1 Hz
LVL2	j400 + j400		1 Hz
LVL2	b300		1 Hz
LVL2	j200	prescale/100	1 Hz
LVL2	j150 + j150	prescale/100	1 Hz
LVL2	j150 + j150 + se800		1 Hz
LVL2	b150 + b15 + b15		7 Hz
LVL2	j100 + e10I + e10I		1 Hz
LVL2	j100 + mu6 + mu6		1 Hz
LVL2	b100 + b30 + b30		8 Hz
LVL2	j100 + j100 + j50 + j50		16 Hz
LVL2	b80 + b80 + b30		2 Hz
LVL2	b50 + b50 + b50		1 Hz
LVL2	j50 + j50 + j50 + e10I		20 Hz
LVL2	j50 + j50 + j50 + mu6		3 Hz
LVL2	b50 + b50 + j50 + j50 + j50		2 Hz
LVL2	j50 + j50 + j50 + j50 + j50 + j50		5 Hz
LVL2	b40 + b40 + b40 + b40		1 Hz
LVL2	me60 + j50 + j50 + e10I		3 Hz
LVL2	me60 + j50 + j50 + mu6		3 Hz
LVL2	me60 + j50 + j50 + j50		8 Hz
LVL2	me80 + j100 + j100		2 Hz
LVL2	me90		3 Hz
LVL2	se1000		1 Hz
LVL2	te1000		1 Hz

SUM of LVL2 triggers (except B-physics)	400 Hz
SUBTOTAL corrected for overlapping triggers	357 Hz
TOTAL LVL2 TRIGGER RATE	657 Hz

6.6 LVL3 Trigger Menu

Only very preliminary work has been done on the Event Filter algorithms referred to here as LVL3. In DAQ-NO-54, the missing-E_t and b-jet tag algorithms were referred to as 'LVL3' algorithms, but it was stated that they could be performed in the LVL2 processors, depending on the choice of the LVL2 architecture. These algorithms have been included in the 'full' LVL2 trigger menus in this new version of the trigger menus.

The tentative LVL3 trigger menu for luminosity 10^{33} cm^{-2} s^{-1} is shown in the following table. It is assumed that b-jet tags at LVL3 have twice the rejection factor of b-jets at LVL2. It is also assumed that the missing-Et resolution is improved by a factor $\sqrt{2}$. For muons, it is assumed that half of the remaining π/K decays are rejected, and that the isolation cuts are improved (including a measurement of the minimum-ionization signal in the calorimeter). Bremsstrahlung corrections are assumed for the electrons, and π^0 rejection for the gammas. In general, a factor two reduction is assumed for single-particle background rates due to the superior algorithms available at LVL3 (Event Filter). Much higher background reductions will be obtained off-line.

EVENT FILTER (LVL3) B-PHYSICS TRIGGERS		*loose mass cuts*
LVL3	mu6 + e1 + e1 + M(J/ψ) + B-vtx	30 Hz
LVL3	mu6 + mu5 + mu3 + M(J/ψ)	20 Hz
LVL3	mu6 + e5 + mu3 + M(J/ψ)	10 Hz
LVL3	mu6 + t6 + t6 + tt15 + M(B) + B-vtx	10 Hz
LVL3	mu6 + t1.5 + t1.5 + t1.5 + M(ϕ^0) + M(D_s) + B-vtx	20 Hz
LVL3	mu6 + mu5 + M(B) + B-vtx	10 Hz
SUM of all LVL3 B-physics triggers		100 Hz
SUM corrected for overlapping triggers		100 Hz

EVENT FILTER (LVL3) HIGH-PT TRIGGER RATES		Events
LVL3	mu60	1 Hz

LVL3	mu40I		4 Hz
LVL3	mu20 + b30 + b30		1 Hz
LVL3	mu20 + g20I		0.2 Hz
LVL3	mu20I + j30 + j30		2 Hz
LVL3	mu20I + j15 + j15 + j15 + j15 + j15 + j15		1 Hz
LVL3	mu20I + me20		12 Hz
LVL3	mu15I + b30		4 Hz
LVL3	mu15I + tau30I		1 Hz
LVL3	mu15I + mu6 + me40		0.1 Hz
LVL3	mu10I + j100		4 Hz
LVL3	mu10I + j40 + j40 + j40 + j40		0.3 Hz
LVL3	mu10I + g15I		1 Hz
LVL3	mu10I + e10I		2 Hz
LVL3	mu10 + mu10		4 Hz
LVL3	mu6 + e10I + e10I		0.3 Hz
LVL3	mu6 + mu6 + e10I		0.3 Hz
LVL3	mu6 + mu6 + mu6		0.3 Hz
LVL3	mu6I + j100 + j100 + me80		0.1 Hz
LVL3	mu6I + e15I + me40		0.3 Hz
LVL3	mu6I + mu6I		5 Hz
LVL3	e200		0.3 Hz
LVL3	g100I		1 Hz
LVL3	e80 + j100		3 Hz
LVL3	e80 + e80		0.1 Hz
LVL3	e80 + me40		0.2 Hz
LVL3	g40I + me40		0.4 Hz
LVL3	e40I		5 Hz
LVL3	e20I + tau40I		1 Hz
LVL3	e20I + j40 + j40		3 Hz
LVL3	e20I + b30 + b30		0.3 Hz
LVL3	$e20I_{\beta}$ + b30		3 Hz
LVL3	$e20I_{\beta}$ + me20		25 Hz
LVL3	e20I + j15 + j15 + j15 + j15 + j15 + j15		6 Hz
LVL3	e20I + e10I		0.5 Hz
LVL3	g20I + g20I		0.5 Hz
LVL3	e15I + j100		4 Hz
LVL3	e15I + e15I		2 Hz
LVL3	e15I + g15I		4 Hz
LVL3	$e10I_{\beta}$ + $e10I_{\beta}$ + b15 + b15		3 Hz
LVL3	e10I + e10I + e10I		0.3 Hz
LVL3	tau200I		2.5 Hz
LVL3	tau150 + me80		0.3 Hz
LVL3	tau80I + tau80I		0.3 Hz
LVL3	tau30I + $e15I_{\beta}$ + me20		2 Hz
LVL3	j500		1 Hz
LVL3	j400 + j400		1 Hz
LVL3	b300		0.5 Hz
LVL3	j200	prescale/100	1 Hz
LVL3	j150 + j150	prescale/100	1 Hz
LVL3	j150 + j150 + se800		1 Hz
LVL3	b150 + b15 + b15		1 Hz
LVL3	j100 + j100 + b50 + b50		0.1 Hz
LVL3	j100 + j100 + j100 + j100		2 Hz
LVL3	b100 + b30 + b30		1 Hz
LVL3	j100 + e10I + e10I		0.3 Hz

LVL3	j100 + mu6 + mu6	0.3 Hz
LVL3	j50 + j50 + j50 + j50 + j50 + j50	5 Hz
LVL3	b50 + b50 + j50 + j50 + j50	0.5 Hz
LVL3	b50 + b50 + b50	0.1 Hz
LVL3	j50 + j50 + j50 + e10I + e10I	0.2 Hz
LVL3	j50 + j50 + j50 + mu6	1.5 Hz
LVL3	me80 + j50 + j50 + j50	0.4 Hz
LVL3	me80 + j50 + j50 + e10I	0.1 Hz
LVL3	me80 + j50 + j50 + mu6	0.1 Hz
LVL3	me90 + j100 + j100	1.0 Hz
LVL3	me100	0.8 Hz
LVL3	se1000	0.5 Hz
LVL3	te1000	0.5 Hz
SUM of LVL3 triggers (except B-physics)		132.5 Hz
SUBTOTAL corrected for overlapping triggers		116.0 Hz
TOTAL LVL3 TRIGGER RATE		216 Hz

The largest contributions to the LVL3 trigger rates are due to leptonic W decays:

W -> μ ν	⇒	mu20I + me20	12 Hz
W -> e ν	⇒	$e20I_{\beta}$ + me20	25 Hz

After correction for overlapping triggers, the LVL3 high-P_t triggers can be decomposed into muon triggers (30%), e/gamma triggers (53%), tau triggers (5%), jet triggers (10%), and missing-E_t triggers (2%).

6.7 Event Filter Data Streams

The ATLAS DAQ will put about 100 Hz of events out to permanent storage. This amounts to 10^9 events in a typical LHC year. One of the tasks of the Event Filter is to sort these events into data streams to facilitate their analysis. (The data stream may be reduced to an event tag permitting rapid access to the selected events.) The data streams should distinguish between events which are needed for the physics analysis (‘signal’ events) and events which are stored for use in background studies in the case that an interesting feature appears in the ‘signal’ event samples. Most of the events (perhaps up to 90%) could be stored in the ‘background’ data samples.

The ‘signal’ data samples would still contain about 10^8 events. The Event Filter data might identify some 100 data streams (or tags), with an average of about 10^6 events per sample. The average event rate into each of these samples would be about 0.1 Hz. This is the trigger strategy that is represented in the Event Filter data streams in the following tables. Note that some of the data streams are entirely contained within data streams for different physics channels. This overlap is removed in the total trigger rates at the end of the tables.

EVENT FILTER B-PHYSICS DATA STREAMS *tight mass cuts*

LVL3F	mu6 + e1 + e1 + M(J/ψ) + B-vtx	10 Hz
LVL3F	mu6 + mu5 + mu3 + M(J/ψ)	6 Hz
LVL3F	mu6 + e5 + mu3 + M(J/ψ)	2 Hz
LVL3F	mu6 + t6 + t6 + tt15 + M(B) + B-vtx	2 Hz
LVL3F	mu6 + t1.5 + t1.5 + t1.5 + M(ϕ) + M(D) + M(B) + B-vtx	2 Hz
LVL3F	mu6 + mu5 + M(B) + B-vtx	2 Hz

SUM of all LVL3F B-physics triggers 24 Hz

SUM corrected for overlapping triggers 24 Hz

EVENT FILTER HIGH-PT DATA STREAMS

		Events	Streams
LVL3F	mu60 + me40	0.3 Hz	W’
LVL3F	mu40 + mu40	0.1 Hz	SRV, Z’
LVL3F	mu20 + g40I	0.1 Hz	Wγ
LVL3F	mu20 + b30 + b30 + b15	0.2 Hz	H^0
LVL3F	mu20I + tau40I	0.1 Hz	A^0, Z
LVL3F	mu20I + b40 + j40 + j40	0.1 Hz	t t
LVL3F	mu20I + j40 + j40 + me40	0.1 Hz	SUSY
LVL3F	mu20I + j40 + j40 + b15	0.3 Hz	A^0
LVL3F	mu20I + b40 + me20	0.3 Hz	top
LVL3F	mu20I + b30 + b30	0.2 Hz	WH, $H^{\pm}$, t t
LVL3F	mu20I + mu20I + b30	0.1 Hz	t t
LVL3F	mu20I + me20	12.0 Hz	W mass
LVL3F	mu20I + 8 * j15	0.3 Hz	SRV
LVL3F	mu15I + g15I + g15I	0.1 Hz	WH
LVL3F	mu15I + mu15I + e7I	0.4 Hz	SUSY
LVL3F	mu15I + e15I	0.1 Hz	A^0, t t, WW
LVL3F	mu15I + e10I + me40	0.1 Hz	SUSY
LVL3F	mu15I + mu6 + me40	0.1 Hz	SUSY
LVL3F	mu10I + j40 + j40 + j40 + j40	0.3 Hz	SUSY
LVL3F	mu10I + mu10I + e7I	0.3 Hz	H^0, SUSY, WZ
LVL3F	mu10I + mu10I	1.8 Hz	A^0, Z, WW
LVL3F	mu6I + j100 + j100 + me80	0.1 Hz	SUSY
LVL3F	mu6I + e15I + me40	0.3 Hz	SUSY
LVL3F	mu6 + e10I + e10I	0.3 Hz	SUSY, WZ
LVL3F	mu6I + mu6I + me40	0.5 Hz	SUSY
LVL3F	mu6I + mu6I + b15 + b15	0.2 Hz	A^0, SUSY
LVL3F	mu6I + mu6I + mu6I	0.1 Hz	H^0, SUSY, WZ
LVL3F	e80 + e60 + j100	0.1 Hz	LQ
LVL3F	e80 + e80	0.1 Hz	QCD, Z’
LVL3F	e80 + me40	0.2 Hz	W’
LVL3F	g40I + me40	0.4 Hz	SUSY
LVL3F	e20I + g60I	0.2 Hz	Wγ
LVL3F	e20I + j100 + j100 + me40	0.1 Hz	SUSY
LVL3F	e20I + j40 + j40 + j40 + j40	0.1 Hz	SUSY
LVL3F	e20I + b40 + j40 + j40	0.1 Hz	t t
LVL3F	e20I + tau40I + b30	0.1 Hz	t t

LVL3F	e20I + tau40I + me15	0.5 Hz	A^0
LVL3F	e20I + tau40I	1.0 Hz	Z
LVL3F	e20I + b30 + b30	0.3 Hz	WH, $H^{\pm}$, t t
LVL3F	e20I + 8 * j15	1.5 Hz	SRV
LVL3F	e20I + g15I + g15I	0.1 Hz	WH
LVL3F	e20I + e10I + e10I	0.1 Hz	SUSY
LVL3F	$e20I_{\beta}$ + b40 + me20	0.3 Hz	top
LVL3F	$e20I_{\beta}$ + me20	25.0 Hz	W mass
LVL3F	g20I + g20I + b15 + b15	0.1 Hz	H^0
LVL3F	g20I + g20I + me40	0.1 Hz	SUSY
LVL3F	g20I + g20I + fwd jets	0.1 Hz	H^0
LVL3F	g20I + g20I	0.5 Hz	H^0
LVL3F	e15I + e15I + me40	0.1 Hz	SUSY
LVL3F	e15I + e15I + b30	0.2 Hz	t t
LVL3F	e15I + e15I + b15 + b15	0.3 Hz	A^0, SUSY
LVL3F	e15I + e15I + e7I	0.2 Hz	H^0, SUSY, WZ
LVL3F	e15I + e15I	2.0 Hz	WW, Z
LVL3F	e10I + e10I + e10I	0.3 Hz	SUSY, WZ
LVL3F	e10I + e10I + mu6I	0.2 Hz	H^0, SUSY, WZ
LVL3F	$e10I_{\beta}$ + $e10I_{\beta}$ + b15 + b15	3.0 Hz	SUSY
LVL3F	tau150 + me80	0.3 Hz	W’
LVL3F	tau80I + tau80I	0.3 Hz	Z’
LVL3F	tau40I + $e20I_{\beta}$	0.4 Hz	A^0
LVL3F	j600	0.3 Hz	QCD
LVL3F	j500 + j500	0.3 Hz	Z’
LVL3F	j200 + j200 + j100 + j100	1.0 Hz	SUSY
LVL3F	j200 + j200 + se800	0.3 Hz	SRV
LVL3F	j100 + j100 + b50 + b50	0.1 Hz	SUSY
LVL3F	b100 + b30 + b30 + b15	0.2 Hz	H^0
LVL3F	b100 + b30 + b30 + NN(bbH)	0.2 Hz	bbH
LVL3F	j100 + e10I + e10I + me80	0.1 Hz	SUSY
LVL3F	j100 + mu6 + mu6	0.3 Hz	SUSY
LVL3F	j50 + j50 + j50 + e10I + e10I	0.2 Hz	SUSY
LVL3F	j50 + j50 + j50 + mu6 + e10I	0.1 Hz	SUSY
LVL3F	j50 + j50 + j50 + mu6 + mu6	0.1 Hz	SUSY
LVL3F	b50 + b50 + b50	0.1 Hz	SUSY
LVL3F	me80 + j50 + j50 + j50	0.4 Hz	SUSY
LVL3F	me80 + j50 + j50 + e10I	0.1 Hz	SUSY
LVL3F	me80 + j50 + j50 + mu6	0.1 Hz	SUSY
LVL3F	me100 + j100 + j100	0.3 Hz	SUSY
LVL3F	me120	0.1 Hz	SUSY
LVL3F	te1500	0.1 Hz	SUSY

SUM of LVL3F triggers (except B-physics)	61.6 Hz
SUBTOTAL corrected for overlapping triggers	56.0 Hz
TOTAL LVL3F TRIGGER RATE	80.0 Hz

The symbols for inclusive (or single) top production is ‘top’; pair production items are indicated by ‘t t’. SUSY studies are indicated by ‘SUSY’. R-parity violating decays of SUSY particles are indicated by ‘SRV’. Leptoquarks are indicated by ‘LA’ and compositeness stcated by ‘QCD’. The largest trigger items are those intended for W mass determinations; they are indicated explicitly by the symbol ‘W mass’. The other large items are the inclusive Z items intended for calibration of the hadronic calorimeter; one of these items also provides the trigger for electronic decays of pairs of W bosons. Some of the items are sent to more than one data stream (or ‘tagged’ for more than one physics analysis).

The trigger items for each of the main physics analyses (with the exception of the B-physics channels) is shown below:

EVENT FILTER HIGH-PT DATA STREAMS		Events	Streams
LVL3F	mu20 + b30 + b30 + b15	0.2 Hz	H^0
LVL3F	b100 + b30 + b30 + b15	0.2 Hz	H^0
LVL3F	g20I + g20I + b15 + b15	0.1 Hz	H^0
LVL3F	g20I + g20I + fwd jets	0.1 Hz	H^0
LVL3F	g20I + g20I	0.5 Hz	H^0
LVL3F	e15I + e15I + e7I	0.2 Hz	H^0, SUSY, WZ
LVL3F	mu10I + mu10I + e7I	0.3 Hz	H^0, SUSY, WZ
LVL3F	e10I + e10I + mu6I	0.2 Hz	H^0, SUSY, WZ
LVL3F	mu6I + mu6I + mu6I	0.1 Hz	H^0, SUSY, WZ
LVL3F	mu20I + b30 + b30	0.2 Hz	WH, $H^{\pm}$, t t
LVL3F	e20I + b30 + b30	0.3 Hz	WH, $H^{\pm}$, t t
LVL3F	mu15I + g15I + g15I	0.1 Hz	WH
LVL3F	e20I + g15I + g15I	0.1 Hz	WH
LVL3F	b100 + b30 + b30 + NN(bbH)	0.2 Hz	bbH
LVL3F	mu20I + j40 + j40 + b15	0.3 Hz	A^0
LVL3F	mu6I + mu6I + b15 + b15	0.2 Hz	A^0, SUSY
LVL3F	e15I + e15I + b15 + b15	0.3 Hz	A^0, SUSY
LVL3F	mu20I + tau40I	0.1 Hz	A^0, Z
LVL3F	e20I + tau40I + me15	0.5 Hz	A^0
LVL3F	tau40I + $e20I_{\beta}$	0.4 Hz	A^0
LVL3F	mu10I + mu10I	1.8 Hz	A^0, Z, WW
LVL3F	mu15I + e15I	0.1 Hz	A^0, t t, WW
LVL3F	mu20I + b30 + b30	0.2 Hz	$H^{\pm}$, WH, t t
LVL3F	e20I + b30 + b30	0.3 Hz	$H^{\pm}$, WH, t t
LVL3F	mu20I + b40 + j40 + j40	0.1 Hz	t t
LVL3F	mu20I + b30 + b30	0.2 Hz	t t, WH, $H^{\pm}$
LVL3F	mu20I + mu20I + b30	0.1 Hz	t t
LVL3F	mu15I + e15I	0.1 Hz	t t, A^0, WW
LVL3F	e20I + b40 + j40 + j40	0.1 Hz	t t
LVL3F	e20I + tau40I + b30	0.1 Hz	t t

LVL3F	e20I + b30 + b30	0.3 Hz	t t, WH, $H^{\pm}$
LVL3F	e15I + e15I + b30	0.2 Hz	t t
LVL3F	mu20I + b40 + me20	0.3 Hz	top
LVL3F	$e20I_{\beta}$ + b40 + me20	0.3 Hz	top
LVL3F	mu20I + j40 + j40 + me40	0.1 Hz	SUSY
LVL3F	mu15I + mu15I + e7I	0.4 Hz	SUSY
LVL3F	mu15I + e10I + me40	0.1 Hz	SUSY
LVL3F	mu15I + mu6 + me40	0.1 Hz	SUSY
LVL3F	mu10I + j40 + j40 + j40 + j40	0.3 Hz	SUSY
LVL3F	mu6 + e10I + e10I	0.3 Hz	SUSY, WZ
LVL3F	mu6I + j100 + j100 + me80	0.1 Hz	SUSY
LVL3F	mu6I + e15I + me40	0.3 Hz	SUSY
LVL3F	mu6I + mu6I + me40	0.5 Hz	SUSY
LVL3F	mu6I + mu6I + b15 + b15	0.2 Hz	SUSY, A^0
LVL3F	mu6I + mu6I + e10I	0.1 Hz	SUSY, H^0, WZ
LVL3F	mu6I + mu6I + mu6I	0.1 Hz	SUSY, H^0, WZ
LVL3F	g40I + me40	0.4 Hz	SUSY
LVL3F	e20I + j100 + j100 + me40	0.1 Hz	SUSY
LVL3F	e20I + j40 + j40 + j40 + j40	0.1 Hz	SUSY
LVL3F	$e10I_{\beta}$ + $e10I_{\beta}$ + b15 + b15	3.0 Hz	SUSY
LVL3F	e20I + e10I + e10I	0.1 Hz	SUSY
LVL3F	g20I + g20I + me40	0.1 Hz	SUSY
LVL3F	e15I + e15I + me40	0.1 Hz	SUSY
LVL3F	e15I + e15I + b15 + b15	0.3 Hz	SUSY, A^0
LVL3F	e15I + e15I + e7I	0.2 Hz	SUSY, H^0, WZ
LVL3F	e10I + e10I + e10I	0.3 Hz	SUSY, WZ
LVL3F	e10I + e10I + mu6I	0.2 Hz	SUSY, H^0, WZ
LVL3F	j200 + j200 + j100 + j100	1.0 Hz	SUSY
LVL3F	j100 + j100 + b50 + b50	0.1 Hz	SUSY
LVL3F	j100 + e10I + e10I + me80	0.1 Hz	SUSY
LVL3F	j100 + mu6 + mu6	0.3 Hz	SUSY
LVL3F	j50 + j50 + j50 + e10I + e10I	0.2 Hz	SUSY
LVL3F	j50 + j50 + j50 + mu6 + e10I	0.1 Hz	SUSY
LVL3F	j50 + j50 + j50 + mu6 + mu6	0.1 Hz	SUSY
LVL3F	b50 + b50 + b50	0.1 Hz	SUSY
LVL3F	me80 + j50 + j50 + j50	0.4 Hz	SUSY
LVL3F	me80 + j50 + j50 + e10I	0.1 Hz	SUSY
LVL3F	me80 + j50 + j50 + mu6	0.1 Hz	SUSY
LVL3F	me100 + j100 + j100	0.3 Hz	SUSY
LVL3F	me120	0.1 Hz	SUSY
LVL3F	te1500	0.1 Hz	SUSY
LVL3F	mu40 + mu40	0.1 Hz	SRV, Z’
LVL3F	mu20I + 8 * j15	0.3 Hz	SRV
LVL3F	e20I + 8 * j15	1.5 Hz	SRV
LVL3F	j200 + j200 + se800	0.3 Hz	SRV
LVL3F	mu60 + me40	0.3 Hz	W’
LVL3F	e80 + me40	0.2 Hz	W’
LVL3F	tau150 + me80	0.3 Hz	W’
LVL3F	tau80I + tau80I	0.3 Hz	Z’
LVL3F	j500 + j500	0.3 Hz	Z’
LVL3F	mu40 + mu40	0.1 Hz	Z’, SRV
LVL3F	e80 + e80	0.1 Hz	Z’, QCD

LVL3F	mu20 + g40I	0.1 Hz	Wγ
LVL3F	e20I + g60I	0.2 Hz	Wγ
LVL3F	mu15I + e15I	0.1 Hz	WW, A^0, t t
LVL3F	mu10I + mu10I	1.8 Hz	WW, A^0, Z
LVL3F	e15I + e15I	2.0 Hz	WW, Z
LVL3F	mu6I + mu6I + mu6I	0.1 Hz	WZ, H^0, SUSY
LVL3F	mu6I + mu6I + e10I	0.1 Hz	WZ, H^0, SUSY
LVL3F	mu6 + e10I + e10I	0.3 Hz	WZ, SUSY
LVL3F	e10I + e10I + e10I	0.3 Hz	WZ, SUSY
LVL3F	e15I + e15I + e7I	0.2 Hz	WZ, H^0, SUSY
LVL3F	e80 + e60 + j100	0.1 Hz	LQ
LVL3F	j600	0.3 Hz	QCD
LVL3F	e80 + e80	0.1 Hz	QCD, Z'
LVL3F	mu10I + mu10I	1.8 Hz	Z, A^0, WW
LVL3F	e15I + e15I	2.0 Hz	Z, WW
LVL3F	mu20I + tau40I	0.1 Hz	Z, A^0
LVL3F	e20I + tau40I	1.0 Hz	Z
LVL3F	mu20I + me20	12.0 Hz	W mass
LVL3F	$e20I_\beta$ + me20	25.0 Hz	W mass

The ‘signal’ data streams listed above include 50% of the high-Pt triggers accepted at LVL3 (EF). This is far more than the 10% figure suggested above. On the other hand, half of the events retained go into a single data stream - the inclusive W decays selected for the W mass calculation. Some of these W events are also present in data streams for more specific physics analyses. If we exclude W events which are present only in the inclusive W data stream, less than 25% of the events accepted by LVL3 remain in the ‘signal’ data streams.

7. Global Trigger Strategies

7.1 Modelling LVL2 Trigger Performance

The low luminosity trigger menus described in DAQ-NO-54 [1] have been used for a number of paper-model studies of the LVL2 trigger system. Several LVL2 trigger strategies have been considered. The ‘minimal’ LVL2 trigger menu (sometimes called the ‘standard’ LVL2 trigger menu because it is similar to the LVL2 trigger described in the ATLAS Technical Proposal [4]) confirms the LVL1 trigger RoIs and applies additional selection requirements to the trigger RoIs (such as requiring matching tracks in the inner detector), but it does not use the non-trigger RoIs found by the LVL1 processors, and it does not recalculate missing-E_t or perform b-jet vertex tag algorithms. The ‘extended’ LVL2 trigger menu includes processing of non-trigger RoIs; it is simply labeled ‘LVL2’ in DAQ-NO-54. The ‘full’ LVL2 trigger menu includes missing-E_t and b-jet vertex tags; it is labeled ‘LVL3’ in DAQ-NO-54, where it was stated that these algorithms ‘may be executed in the same processor farm as the LVL2 algorithms’.

The paper-model studies were initially intended to compare system performance for different LVL2 architectures - in particular the ‘local/global’ architecture (‘architecture B’) and the ‘single-farm’ architecture (‘architecture C’). The ‘local/global’ architecture was designed for parallel processing of data from different subdetectors and from different RoIs. The ‘single-farm’ architecture was designed for sequential processing and sequential selection, to avoid performing unnecessary computations on events which could be rejected quickly. Algorithms such as the TRT full scan, the missing-Et recalculation, and the b-jet vertex tags cannot be performed on all events without a major waste of computing power.

Most of these paper model studies have been performed using the standard hardware performance parameters described in DAQ-NO-70 [31]. These standard parameters include computing power 1000 x 500 MIPS for LVL2 and 1000 x 1000 MIPS for LVL3, network bandwidths of 100-155 Mbit/s, I/O overheads of 10 μs, and context switch overheads of 40 μs.

The best results obtained to date for the ‘full’ LVL2 trigger menus are based on a system design using a 1024-port ATM switching network [35]. Some improvements have been introduced in the process model to increase the system performance. These studies show high occupation levels for several of the system components. The calorimeter and TRT RSIs have 100% occupation at the maximum LVL1 rate of 100 kHz. In addition, 3000 LVL2 processors are required, exceeding the number in the current costing model, mainly because of the long execution times assumed for the b-jet vertex tags (250 ms). Finally, the calorimeter network links increase from 60% occupation for LVL2 traffic to 80% occupation when 1 kHz of Event Filter traffic is transferred over the same links.

7.2 Evolution of Hardware Performance

Improvements in the hardware performance can be obtained by increasing the size of the switching network and upgrading the power of the LVL2 processors. Processors with 500 MIPS performance are available and cost-effective today. We can expect that processors purchased after 2002 will have a performance of at least 2000 MIPS. This would provide enough computing power for the expected LVL2 algorithms, as long as the rate of b-jet tags is kept under control. The RSI and network bottlenecks could be resolved by increasing the number of ports (from 1024 to about 1536). The LVL2 traffic and processing required by the low-luminosity trigger menus described here can be accommodated with these improved hardware parameters. Alternative solutions based on a 1024-port switching network will be described below.

A full evaluation of hardware evolution is now in progress in the LVL2 group. It seems probable that by the time of the LVL2 hardware purchases in about 2002, almost all of the performance parameters will be improved by a factor of 4 with respect to our previous estimates [31]. The major exception might be the I/O overhead currently measured to be 10 μs; we hesitate to predict major improvement in this parameter. A credible preliminary set of parameters for ATLAS T/DAQ performance would be the following:

LVL2 CPU	2000 MIPS	50 SpecInt95	
LVL3 CPU	4000 MIPS	100 SpecInt95	
Network BW	622 Mbit/s	ATM	*cost ?*
	1000 Mbit/s	(Giga) Ethernet	*performance ?*
PCI bus BW	528 Mbyte/s	66 Mhz × 64 bits	
Context switch	10 μs		
I/O overhead	10 μs	*assuming no improvement*	
R/O buffer size	16 MB	*not necessary*	

All of these parameters, with the exception of the I/O overhead, are 4 times better than previously assumed for LVL2 modelling studies. On the other hand, DAQ/EF studies already assume that 1000 Mbit/s network links will be available for event building. Note that we assume that the LVL3 (EF) processors will be twice as powerful as the LVL2 processors because they will be purchased two years later.

The improvement in the switching network bandwidth is technologically possible, but serious questions remain in practice. The 622 Mbit/s ATM interfaces can be purchased today, but today's cost for a 1024-port system would largely exceed the available funds. If the cost does not decrease sufficiently before the purchase date, we could build an ATM network using the faster links only where it proves to be necessary. The questions about the GigaEthernet switching network concern future performance, more than future cost.

Paper model studies have been performed to evaluate the system performance with the improved hardware listed above [35]. These studies show that the RSI occupations for the ECAL and TRT subdetectors are still about 80%, for a 100 kHz LVL1 rate, with the higher-performance hardware, but the number of LVL2 processors is reduced to an acceptable number (about 1000 processors at 70% occupation). The ECAL RSI bottleneck can be resolved (occupation below 60%) by assigning 2 ECAL ROBs per RSI instead of the standard 4; the full system, including the Event Filter SFIs, will still fit onto the 1024-port switching network. (The TRT RSI problem can be shunted aside if the TRT full scan is performed on separate FPGA processors.) Alternatively, the RSI bottlenecks for both the ECAL and the TRT would be resolved if the I/O overheads could be reduced to 5 μs (a factor two reduction from today's values).

7.3 LVL2 Trigger Strategies

The full LVL2 trigger menu includes missing-E_t recalculation and b-jet vertex tags. These LVL2 trigger algorithms have been identified as 'desirable' LVL2 requirements, but they are not 'mandatory'. Recalculation of the missing-E_t at LVL2 requires data from all of the calorimeter towers, so the feasibility of the algorithm depends on the LVL2 hardware configuration. The configuration chosen at the recent internal LVL2 review is compatible with the missing-E_t recalculation, because all of the ROBs are accessible to all of the LVL2 processors. The feasibility of the b-jet vertex tag, on the other hand, depends on the performance of the LVL2 algorithm, as well as on the hardware configuration. The performance depends on the SCT and pixel alignment and calibration and the stability of these parameters, as well as the quality of the LVL2 code. If a successful b-jet vertex tag cannot be developed for LVL2, this algorithm will be performed only at LVL3 (EF).

For a given physics menu, the resources necessary (switching network bandwidth and processing power) would be increased significantly if all b-jet candidates must be transferred to LVL3 for analysis. All of the event data must be transferred to the Event Filter for events accepted by LVL2, whereas the LVL2 processing uses typically less than 5% of the event data. Similarly, execution times for the LVL3 algorithms will be much longer than the execution times of the corresponding LVL2 algorithms. On the other hand, the LVL3 algorithms will have higher performance, in terms of resolution and rejection power, than the faster LVL2 algorithms. It is reasonnable to suppose that the b-jet vertex tag will be effective at LVL3 even if it is unsuccessful, or of poor quality, at LVL2.

This suggests that two (sequential) trigger strategies should be considered for LVL2: the 'full' LVL2 trigger menu listed in Section 6.5, and a 'restricted' LVL2 trigger menu without b-jet vertex tags. The 'restricted' LVL2 trigger menu would be obtained by adding the b-jet vertex tag input menu (LVL2_bv) to the 'full' LVL2 trigger menu, and removing the items that become redundant. The sum of the high-P_t trigger rates for the 'restricted' menu would be about 2 kHz for a LVL1 rate of 50 kHz. This would be an acceptable design parameter if the expected system performance were compatible with a maximum LVL2 trigger rate of 4 kHz.

On the other hand, the physics potential would be enhanced at low luminosity if any extra bandwidth were allocated to additional B-physics channels, instead of using it to select b-jet candidates that could have been eliminated at LVL2.

At high luminosity, almost all of the available band will be devoted to high-P_t physics channels. The balance between muon triggers and calorimeter triggers is likely to lean further toward the calorimeter, and away from the TRT. More study is needed to evaluate the effect on the LVL2 system performance, but some upgrade of the calorimeter ROBs and RSIs may be required.

7.4 LVL3 Trigger Strategies

The Event Filter trigger strategy up until now has been to use off-line reconstruction code as much as possible and to avoid developing specific Event Filter algorithms [36]. Recent benchmarking results have imposed a review of possible alternative LVL3/EF trigger strategies [37]. Three general LVL3/EF trigger strategies can be considered:

- A ‘full-analysis’ strategy in which full event reconstruction is performed in the LVL3/EF processors for all events accepted at LVL2.

- A ‘sequential Event Filter’ strategy similar to the LVL2 sequential strategy. LVL3/EF processing would be guided by the results obtained at LVL1 and LVL2, including RoI information. Full event reconstruction would be performed only for events accepted at LVL3.

- A ‘minimal LVL3’ strategy using sequential processing, except that the processing is stopped as soon as a decision has been made to reject or accept the event. No full event reconstruction is performed.

The benchmarking results referred to above were presented at a recent Event Filter meeting by David Rousseau [38]. Off-line algorithms were run on a 400 MIPS processor (10 SpecInt95). Electron/gamma algorithms in the calorimeter, without RoI guidance, executed on average in about 1 second at low luminosity and 10 seconds at high luminosity. Tracking in the inner detector took 100 ms at low luminosity and 4 seconds at high luminosity for an electron in a RoI. B-jet tagging for b-jets from the decay of a 400 GeV H^0 took 12 seconds at low luminosity and 100 seconds at high luminosity. Full event reconstruction for the H^0 events required 350 seconds at high luminosity. Full event reconstruction at low luminosity could be expected to take at least 30 seconds. If we assume that the EF will have 4000 MIPS processors, about 5,000 processors (at 70% occupation) would be required for full analysis at the nominal LVL2 trigger rate of 1 kHz.

The ‘full-analysis’ strategy could be maintained at low luminosity if the input rate is limited to 1 kHz and if the off-line code could be optimized by a factor of about 5. The number of processors would then fit the CORE costing limit of 1000. This could well be achieved without requiring a profound change in the EF trigger strategy. On the other hand, if the LVL2 trigger rate were increased to 4 or 10 kHz, a different trigger strategy should surely be considered. At high luminosity, the full-analysis strategy should be abandoned even for a 1 kHz input rate.

The ‘sequential EF’ trigger strategy would reduce the processor needs by about 80% with respect to the ‘full-analysis’ strategy. About half of the remaining processing power would be required for the full analysis of the events accepted for permanent storage (10% of the events accepted by LVL2). This strategy could be applied at low luminosity without further optimization of the EF code if the input rate is limited to 1 kHz. Higher LVL2 trigger rates could be accepted at low luminosity after optimization of the EF code. For high luminosity, the sequential EF strategy should work if the input rate is limited to no more than about 1 kHz. Note that the sequential EF strategy does not change the analysis of accepted events, so the full Event Filter functionality is preserved, including the preparation of data summaries and event tags to guide the off-line reconstruction and analysis.

The 'minimal LVL3' trigger strategy would reduce the processing requirements by about a factor two with respect to the 'sequential EF' strategy. This option is called 'minimal LVL3' because some of the Event Filter functionality, such as preparation of full data summaries and event tags, would be abandoned.

At high luminosity, the LVL3 options are even more limited because the execution times for the off-line code are typically 10 times longer than at low luminosity. The difficulty could be limited by transferring some of the LVL3 trigger algorithms to LVL2. There is also the possibility of upgrading the LVL3 processors, since the high-luminosity running is expected to start some 4 years after the initial LHC operation [39], [40]. Nonetheless, the 'minimal LVL3' option could be the only strategy available at high luminosity if the optimization and upgrades are insufficient.

7.5 Global Trigger Strategies for LVL2 plus LVL3

The execution times we can deduce for the LVL3/EF algorithms are much longer than the execution times estimated for the corresponding stand-alone LVL2 trigger algorithms. The off-line code requires 40 ms to analyze a single energy cluster in the calorimeter; we expect the simpler LVL2 algorithm to run in less than 100 μs on a comparable machine. The b-jet vertex tag requires about 6 seconds per jet with the off-line code; a much simpler algorithm based on the pixel detectors alone has given good results with an average execution time of only 1 ms [27]. We expect that the off-line code can be optimized to reduce the execution time, perhaps by a factor of 10 or so. Nonetheless, the intital benchmarking of off-line algorithms that could be used at LVL3 indicates that we have every interest to run simple forms of complex algorithms at LVL2, rather than sending the events to LVL3 for analysis.

We have seen in the previous section that the possible LVL3 trigger strategies depend on the LVL3 input rate (i.e., the LVL2 trigger rate). For the LVL3 trigger menu given in this note, the LVL2 trigger rate depends on whether the b-jet vertex tags are performed initially at LVL2 or at LVL3. We can make the following assumptions:

- The hardware performance described in Section 7.2 will be available for ATLAS.
- The off-line code can be optimized by up to a factor 10, but no more.
- LVL3 will accept 10% of the events input from LVL2.
- The events accepted at LVL3 must be fully analyzed to respect the EF functionality.

Then the following three global trigger strategies could be envisaged (by order of preference):

1) Full LVL2 trigger menus (including b-jet tags) at low and high luminosity.
   Sequential Event Filter strategy at low and high luminosity.

2) Full LVL2 trigger menus at low and high luminosity.
   Full EF analysis at low luminosity; sequential EF at high luminosity.

3) Restricted LVL2 (no b tags) at low luminosity; full LVL2 at high luminosity.
   Sequential EF at low and high luminosity.

8. Conclusions

Trigger menus for the LVL1, LVL2, and LVL3 ATLAS triggers at luminosity 10^{33} cm^{-2} s^{-1} have been proposed in this note, based on ATLAS physics requirements. A catalog of trigger algorithms proposed for each of the physics channels discussed by the ATLAS physics groups is included as an appendix to this note. The trigger items presented are based on a sequential LVL2 selection procedure. The trigger rates given are 'best guess' values, based on those simulations that have been carried out plus the physics limits due to known production rates.

The LVL1 trigger rate presented here is more than half of the 75 kHz limit. The high-p_T trigger rates are about 350 Hz at LVL2 and 120 Hz at LVL3; B physics doubles these trigger rates. These LVL2 and LVL3 trigger rates are compatible with the ATLAS trigger requirements. Very preliminary Event Filter selection criteria could reduce the number of events destined for full analysis to about 60 Hz.

APPENDIX A

Catalog of Physics Processes and Proposed Trigger Menu Items

The catalog of ATLAS physics processes used to determine the trigger menus proposed in this note are taken almost entirely from the work of the ATLAS physics groups. The main references are the Technical Proposal [4] and the MSSM Higgs work presented by E. Richter-Was, et al, in Ref.[5]. (Although many of the back-up documents referred to in the T.P. have been used in the course of this work, we have not attempted to include all of these references explicitly in this report. They can be found in the reference list in the T.P.)

Our understanding of the jet and missing-E_t trigger requirements is based largely on work presented at the ATLAS SUSY Workshop in Stockholm in January 1996 and at the ATLAS LVL2 Workshop in Cracow in April 1996.

The $H^0 \rightarrow h^0 h^0 \rightarrow b\,b\,b\,b$ channel has been studied at Saclay, in collaboration with ANL and with E. Richter-Was and the ATLAS SUSY Working Group.

The section on SUSY decays (Section A.3) has been modified for this second version of the trigger menus to include the physics analyses presented at the LHCC SUSY Workshop which was held at CERN in October 1996 [7].

Heavy vector boson decays into electron pairs, muon pairs, and, especially t-pairs, have been added without specific physics simulations, even at the parton level. Inclusive leptonic W and Z decays have been included as a physics source and for calibration. Inclusive single-particle triggers have also been included; their thresholds can be increased as needed to limit their impact on the total LVL3 trigger rate.

The rest of this appendix is the catalog of these physics processes and the proposed trigger algorithms. For each physics process, we give a reference to the relevant section of the Technical Proposal or a reference to a more specific physics analysis, as well as a (partial) set of cuts used in the physics analysis of low luminosity. In cases where the physics analysis was studied only at high luminosity, the cuts are flagged as high-luminosity cuts. In a very small number of cases, physics processes proposed for high luminosity have been left out of the present catalog.

For each physics process, sample LVL1, LVL2, and LVL3 trigger algorithms are proposed. LVL3 data stream flags (LVL3F) are indicated where relevant.

A.1. Higgs Bosons

A.1.1. Light Higgs (80 GeV < M < 120 GeV)

$H \rightarrow \gamma\gamma$

Physics analysis reported in Section 11.2 of the Technical Proposal [4].

physics g40I + g25I

LVL1	EM10I + EM10I	9 330 Hz
LVL2	g20I + g20I	2 Hz
LVL3	g20I + g20I	0.5 Hz
LVL3F	g20I + g20I	0.5 Hz

$W + H \rightarrow e^{\pm}\nu + \gamma\gamma$

Physics interest reported by M. Spira [41].

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + g15I	12 Hz
LVL3	e15I + g15I	4 Hz
LVL3F	e20I + g15I + g15I	0.1 Hz

$W + H \rightarrow \mu^{\pm}\nu + \gamma\gamma$

Physics interest reported by M. Spira [41].

LVL1	MU6	23 000 Hz
LVL2	mu10I + g15I	4 Hz
LVL3	mu10I + g15I	1 Hz
LVL3F	mu15I + g15I + g15I	0.1 Hz

$q\,q + H \rightarrow q\,q + \gamma\gamma$

physics g20I + g20I + forward jets Zeppenfeld [42]

LVL1	EM10I + EM10I	9 330 Hz
LVL2	g20I + g20I	2 Hz
LVL3	g20I + g20I	0.5 Hz
LVL3F	g20I + g20I + fwd jets	0.1 Hz

$q\,q + H \rightarrow q\,q + \tau^{+}\tau^{-}$

physics lepton + hadron + forward jets Zeppenfeld [42]

Z + H

physics interest reported by Spira.

$H \rightarrow Z + \gamma$

physics interest reported at Grenoble [43]

W + H $\rightarrow$ $e^{\pm}$ ν + b b

Physics analysis reported in Section 11.3.2 of the Technical Proposal [4].

physics	e30I + b15 + b15	
LVL1	EM20I	11 980 Hz
LVL2	e20I + b30 + b30	3 Hz
LVL3	e20I + b30 + b30	0.3 Hz
LVL3F	e20I + b30 + b30	0.3 Hz

W + H $\rightarrow$ $\mu^{\pm}$ ν + b b

Physics analysis reported in Section 11.3.2 of the Technical Proposal [4].
Muon threshold increased to 15 GeV, 1 June 1998.

physics	mu6I + b15 + b15	
LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I + b30 + b30	0.2 Hz

t t + H $\rightarrow$ $e^{\pm}$ ν + b b + b b

Physics analysis reported in Section 11.3.3 of the Technical Proposal [4].
The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics	e30I + b15 + b15 + b15	
LVL1	EM20I	11 980 Hz
LVL2	e20I + b30 + b30	3 Hz
LVL3	e20I + b30 + b30	0.3 Hz
LVL3F	e20I + b30 + b30	0.3 Hz

t t + H $\rightarrow$ $\mu^{\pm}$ ν + b b + b b

Physics analysis reported in Section 11.3.3 of the Technical Proposal [4].
The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics	mu6I + b15 + b15 + b15	
LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I + b30 + b30	0.2 Hz

b b + H $\rightarrow$ b b + b b

This channel was discussed in Section 11.3 of the Technical Proposal [4], but it was considered to be "impossible to trigger on efficiently, even at the initial lower luminosity." The present cuts were suggested by an analysis published by J. Dai, J. Gunion, and R. Vega [44]; the physics analysis is under study by J. Bystricky and R. Hubbard [45]. The use of neural networks in the Event Filter is under study in a cooperative effort by Saclay and Prague [46].

physics	b100 + b15 + b15	
LVL1	J100	2 290 Hz
LVL2	b100 + b30 + b30	8 Hz
LVL3	b100 + b30 + b30	1 Hz
LVL3F	b100 + b30 + b30 + NN(bbH)	0.2 Hz

A.1.2. Intermediate Mass Higgs (130 GeV < M < 800 GeV)

$H \to Z Z^* \to e^+ e^- e^+ e^-$

Physics analysis reported in Section 11.5.2.1 of the Technical Proposal [4]. The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}). One of the lepton pairs is required to have a mass within 6 GeV of the Z mass; the other pair is required to have a mass greater than 20 GeV

physics	e20 + e20 + e7 + e7 + M(Z) + M(Z*)	
LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + e7I	0.2 Hz

$H \to Z Z^* \to \mu^+ \mu^- \mu^+ \mu^-$

Physics analysis reported in Section 11.5.2.2 of the Technical Proposal [4]. The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics	mu20 + mu20 + mu7 + mu7 + M(Z) + M(Z*)	
LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + mu6I	0.1 Hz

$H \to Z Z^* \to e^+ e^- \mu^+ \mu^-$

Physics analysis reported in Section 11.5.2.3 of the Technical Proposal [4]. The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics	e20 + e20 + mu7 + mu7 + M(Z) + M(Z*)	
LVL1	MU6	23 000 Hz
LVL2	mu6 + e10I + e10I	1 Hz
LVL3	mu6 + e10I + e10I	0.3 Hz
LVL3F	mu6I + e10I + e10I	0.2 Hz

physics	mu20 + mu20 + e7 + e7 + M(Z) + M(Z*)	
LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu10I + mu10I + e7I	0.3 Hz

A.1.3. Higgs Sector in MSSM

A, H $\rightarrow \tau^+ \tau^- \rightarrow \mu$ + hadrons

Physics analysis reported in ATLAS internal note PHYS-NO-51 [30].
Note that the missing-E_t cuts, in particular, assume that the full resolution has not been obtained at the Event Filter level. The cuts are meant to permit to good efficiency (90%) after off-line cuts at the nominal trigger thresholds.

physics	mu24I + tau40 + me18 + ...	
LVL1	MU6	23 000 Hz
LVL2	mu15I + tau20I	3 Hz
LVL3	mu15I + tau30I	1 Hz
LVL3F	mu20I + tau40I	0.1 Hz

A, H$\rightarrow \tau^+ \tau^- \rightarrow$ e + hadrons

Physics analysis similar to that for mu + hadrons reported in PHYS-NO-51 [30].
Note that the missing-E_t cuts, in particular, assume that the full resolution has not been obtained at the Event Filter level. The cuts are meant to permit to good efficiency (90%) after off-line cuts at the nominal trigger thresholds.

physics	e24I + tau40 + me18 + ...	
LVL1	EM20I	11 980 Hz
LVL2	e20I + tau40I	4 Hz
LVL3	e20I + tau40I	1 Hz
LVL3F	e20I + tau40I + me15	0.5 Hz
LVL1	EM20I	11 980 Hz
LVL2	e20I + tau40I	4 Hz
LVL3	e20I + tau40I	1 Hz
LVL3F	$e20I_\beta$ + tau40I	0.4 Hz

A, H $\rightarrow \tau^+ \tau^- \rightarrow \mu$ + e

Physics analysis reported in ATLAS internal note PHYS-NO-51 [30].
Note that the missing-E_t cuts, in particular, assume that the full resolution has not been obtained at the Event Filter level. The cuts are meant to permit to good efficiency (90%) after off-line cuts at the nominal trigger thresholds.

physics	mu15 + e15 + me15 + ...	
LVL1	MU6	23 000 Hz
LVL3	mu10I + e10I	8 Hz
LVL3	mu10I + e10I	2 Hz
LVL3F	mu15I + e15I	0.1 Hz

A, H $\rightarrow \mu^+ \mu^-$

Physics analysis reported in ATLAS internal note PHYS-NO-74 [5].

physics	mu20 + mu20	
LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz

LVL3	mu10 + mu10	4 Hz
LVL3F	mu10I + mu10I	1.8 Hz

$A \rightarrow Z\ h \rightarrow e^+\ e^- + b\ b$

Physics analysis reported in ATLAS internal note PHYS-NO-74 [5].

physics e20 + e20 + b15 + b15 + M(Z)

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + b15 + b15	0.3 Hz

$A \rightarrow Z\ h \rightarrow \mu^+\ \mu^- + b\ b$

Physics analysis reported in ATLAS internal note PHYS-NO-74 [5].

physics mu20 + mu20 + b15 + b15 + M(Z)

LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + b15 + b15	0.2 Hz

$A, H \rightarrow t\ t \rightarrow W\ b + W\ b \rightarrow e\ \nu\ b + j\ j\ b$

Physics analysis reported in ATLAS internal note PHYS-NO-74 [5].

physics e20 + j40 + j40 + b15 + b15

LVL1	EM20I	11 980 Hz
LVL2R	e20I + j40	80 Hz
LVL2	e20I + j40 + j40	10 Hz
LVL3	e20I + j40 + j40 + b15	1 Hz
LVL3F	e20I + j40 + j40 + b15 + b15	0.1 Hz ??

$A, H \rightarrow t\ t \rightarrow W\ b + W\ b \rightarrow \mu\ \nu\ b + j\ j\ b$

Physics analysis reported in ATLAS internal note PHYS-NO-74 [5].

physics mu20 + j40 + j40 + b15 + b15

LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I + j40 + j40 + b15	0.3 Hz

$H^0 \rightarrow h^0\ h^0 \rightarrow \gamma\gamma\ b\ b$

physics analysis reported in ATLAS internal note PHYS-NO-74 [5].

Physics g20I + g20I + b15 + j15

LVL1	EM10I + EM10I	9 330 Hz
LVL2	g20I + g20I	2 Hz
LVL3	g20I + g20I	0.5 Hz

LVL3F	g20I + g20I + b15 + j15	0.1 Hz

$H^0 \rightarrow h^0 h^0 \rightarrow b\, b\;\; b\, b \rightarrow c\, \mu\, \nu + j\, j\, j$

LVL1	MU6	23 000 Hz
LVL2	mu20 + b30 + b30	6 Hz
LVL3	mu20 + b30 + b30	1 Hz
LVL3F	mu20 + b30 + b30 + b15	0.2 Hz

$H^0 \rightarrow h^0 h^0 \rightarrow b\, b\;\; b\, b \rightarrow j\;\; j\;\; j\;\; j$

Physics analysis reported by J. Bystricky, ATLAS SUSY Working Group Meeting, CERN, March 1996.

physics	b100 + b15 + b15 + b15	
LVL1	J100	2 290 Hz
LVL2	b100 + b30 + b30	8 Hz
LVL3	b100 + b30 + b30	1 Hz
LVL3F	b100 + b30 + b30 + b15	0.2 Hz

$h^0 \rightarrow$ neutralino$_1$ neutralino$_1$ $\rightarrow$ missing-E_t

Physics interest reported by M. Spira [41].
Decay modes discussed by Djouadi, et al. [47]

$A^0 \rightarrow$ neutralino$_1$ neutralino$_3$ $\rightarrow$ leptons + jets + missing-E_t

Physics interest reported by M. Spira [41].
Decay modes discussed by Djouadi, et al. [47]

SUSY triggers.

$A^0 \rightarrow$ chargino$_1$ chargino$_2$ $\rightarrow$ leptons + jets + missing-E_t

Physics interest reported by M. Spira [41].
Decay modes discussed by Djouadi, et al. [47]

SUSY triggers.

$H^+ \rightarrow$ chargino$_2$ neutralino$_1$ $\rightarrow$ leptons + jets + missing-E_t

Physics interest reported by M. Spira [41].
Decay modes discussed by Djouadi, et al. [47]

SUSY triggers.

$H^0 \rightarrow$ stop stop

Physics interest reported by M. Spira [41].

SUSY t tbar trigger.

$H^0 \rightarrow$ sbottom sbottom

Physics interest reported by M. Spira [41].

$H^+ \to \tau^+ \nu$

Physics interest reported by M. Spira [41].
Physics analysis discussed in ATLAS internal note PHYS-NO-74 [5].
Preferred mode is $t \to b H^+$ followed by $H^+ \to \tau^+ \nu$.
See section A.2.4, Rare Top Decays.

$H^+ \to W^+ h$

Physics interest reported by M. Spira [41].
Same triggers as W + H. See Section A.1.1.

$H^+ \to t\,b \to W\,b\,b \to$ e nu + b b

LVL1	EM20I	11 980 Hz
LVL2	e20I + b30 + b30	3 Hz
LVL3	e20I + b30 + b30	0.3 Hz
LVL3F	e20I + b30 + b30	0.3 Hz

$H^+ \to t\,b \to W\,b\,b \to \mu$ nu + b b

Physics interest reported by M. Spira [41].

LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I + b30 + b30	0.2 Hz

A.1.4. Strongly Interacting Higgs

$W^+ W^+ \to e^+ e^+$

Physics analysis reported in Section 11.9.1 of the Technical Proposal [4].
The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics e25 + e25 + ...

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I	2 Hz

$W^+ W^+ \to \mu^+ \mu^+$

Physics analysis reported in Section 11.9.1 of the Technical Proposal [4].
The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics mu25 + mu25 + ...

LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz
LVL3	mu10 + mu10	4 Hz
LVL3F	mu10I + mu10I	1.8 Hz

$W^+ W^+ \rightarrow \mu^+ e^+$

physics	mu25 + e25 + ...	
LVL1	MU6	23 000 Hz
LVL3	mu10I + e10I	8 Hz
LVL3	mu10I + e10I	2 Hz
LVL3F	mu15I + e15I	0.1 Hz

A.2. Top Quarks

A.2.1. Top Quark Mass

$t\,t \rightarrow W\,b + W\,b \rightarrow e\,\nu + b + j\,j + b$

Physics analysis reported in Section 11.10.1.1 of the Technical Proposal [4].

physics	e20I + j40 + j40 + b40 + M(j j)=MT(W)	
LVL1	EM20I	11 980 Hz
LVL2	e20I + j40 + j40	6 Hz
LVL3	e20I + j40 + j40	3 Hz
LVL3F	e20I + b40 + j40 + j40	0.1 Hz

$t\,t \rightarrow W\,b + W\,b \rightarrow \mu\,\nu + b + j\,j + b$

Physics analysis reported in Section 11.10.1.1 of the Technical Proposal [4].

physics	mu20I + j40 + j40 + b40 + M(j j)=M(W)	
LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I + b40 + j40 + j40	0.1 Hz

$t\,t \rightarrow W\,b + W\,b \rightarrow e^+\,\nu + b + e^-\,\nu + c\,e^+\,\nu$

Physics analysis reported in Section 11.10.1.2 of the Technical Proposal [4].

physics	e20I + e20I + e15	
LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + b30	0.2 Hz

$t\,t \rightarrow W\,b + W\,b \rightarrow e^+\,\nu + b + e^-\,\nu + c\,\mu^+\,\nu$

Physics analysis reported in Section 11.10.1.2 of the Technical Proposal [4].

physics	e20I + e20I + mu15	
LVL1	EM10I + EM10I	9 330 Hz

LVL2	e10I + e10I + mu6	1 Hz
LVL3	e10I + e10I + mu6	0.3 Hz
LVL3F	e10I + e10I + mu6	0.3 Hz

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + b30	0.2 Hz

$t\,t \rightarrow W\,b + W\,b \rightarrow e^+ \nu + b + \mu^- \nu + c\, e^+ \nu$

Physics analysis reported in Section 11.10.1.2 of the Technical Proposal [4].

physics mu20I + e20I + e15

LVL1	MU6	23 000 Hz
LVL3	mu10I + e10I	8 Hz
LVL3	mu10I + e10I	2 Hz
LVL3F	mu15I + e15I	0.1 Hz

$t\,t \rightarrow W\,b + W\,b \rightarrow e^+ \nu + b + \mu^- \nu + c\, \mu^+ \nu$

Physics analysis reported in Section 11.10.1.2 of the Technical Proposal [4].

physics mu20I + e20I + mu15

LVL1	MU6	23 000 Hz
LVL3	mu10I + e10I	8 Hz
LVL3	mu10I + e10I	2 Hz
LVL3F	mu15I + e15I	0.1 Hz

$t\,t \rightarrow W\,b + W\,b \rightarrow \mu^+ \nu + b + \mu^- \nu + c\, e^+ \nu$

Physics analysis reported in Section 11.10.1.2 of the Technical Proposal [4].

physics mu20I + mu20I + e15

LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz
LVL3	mu10 + mu10	4 Hz
LVL3F	mu20I + mu20I + b30	0.1 Hz

$t\,t \rightarrow W\,b + W\,b \rightarrow \mu^+ \nu + b + \mu^- \nu + c\, \mu^+ \nu$

Physics analysis reported in Section 11.10.1.2 of the Technical Proposal [4].

physics mu20I + mu20I + mu15

LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz
LVL3	mu10 + mu10	4 Hz
LVL3F	mu20I + mu20I + b30	0.1 Hz

A.2.2. Single Top Production and Inclusive Top Quark Decays

$t \rightarrow W b \rightarrow e^+ \nu + b$

Inclusive top decays can be selected by requiring a leptonic decay of the other top, $t \rightarrow W b \rightarrow$ lepton $\nu + b$. These triggers are also effective for single top production.

LVL1	EM20I	11 980 Hz
LVL2	$e20I_\beta + b30$	10 Hz
LVL3	$e20I_\beta + b30$	3 Hz
LVL3F	$e20I_\beta + b40 + me20$	0.3 Hz

LVL1	EM20I	11 980 Hz
LVL2	$e20I_\beta + me20$	50 Hz
LVL3	$e20I_\beta + me20$	25 Hz
LVL3F	$e20I_\beta + b40 + me20$	0.3 Hz

$t \rightarrow W b \rightarrow \mu^+ \nu \; b$

Inclusive top decays can be selected by requiring a leptonic decay of the other top, $t \rightarrow W b \rightarrow$ lepton ν b.

LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + me20	12 Hz
LVL3F	mu20I + b40 + me20	0.3 Hz

LVL1	MU6	23 000 Hz
LVL2	mu15I + b30	12 Hz
LVL3	mu15I + b30	4 Hz
LVL3F	mu20I + b40 + me20	0.3 Hz

A.2.3. Top Decays for Calorimeter Calibration

t tbar → W b W b → e+ nu + b bbar + jets

Calorimeter calibration discussed at the ATLAS Physics meeting, 28 November 1996, by P. Savard [48].

calibration e20I + W → jet jet

LVL1	EM20I	11 980 Hz
LVL2	e20I + b30 + b30	3 Hz
LVL3	e20I + b30 + b30	0.3 Hz
LVL3F	e20I + b30 + b30	0.3 Hz

t tbar → W b W b → mu+ nu + b bbar + jets

Calorimeter calibration discussed at the ATLAS Physics meeting, 28 November 1996, by P. Savard [48].

calibration mu20I + W → jet jet

LVL1	*MU6*	*23 000 Hz*
LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I + b30 + b30	0.2 Hz

A.2.4. Rare Top Decays

t t $\rightarrow$ W b + H^- b $\rightarrow$ $e^+ \nu$ + b + $\tau^- \nu$ + b

Physics analysis reported in Section 11.10.2 of the Technical Proposal [4]. The second set of triggers does not strictly respect the physics cuts proposed in the Technical Proposal, but it is more specific to the decay mode desired.

physics e20I + b20 + b20 + j20

LVL1	EM20I	11 980 Hz
LVL2	e20I + b30 + b30	3 Hz
LVL3	e20I + b30 + b30	0.3 Hz
LVL3F	e20I + b30 + b30	0.3 Hz

LVL1	EM20I	11 980 Hz
LVL2	e20I + tau40I	4 Hz
LVL3	e20I + tau40I	1 Hz
LVL3F	e20I + tau40I + b30	0.1 Hz

t t $\rightarrow$ W b + Z c $\rightarrow$ j j + b + $e^+ e^-$ + c

Physics analysis reported in Section 11.10.3 of the Technical Proposal. Specific thresholds for the leptons are not given in the T.P.

physics e + e + b50 + j50 + j50 + M(Z)

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + b30	0.2 Hz

LVL1	EM20I	11 980 Hz
LVL2	e20I + j40 + j40	6 Hz
LVL3	e20I + j40 + j40	3 Hz
LVL3F	e20I + b40 + j40 + j40	0.1 Hz

t t $\rightarrow$ W b + Z c $\rightarrow$ j j + b + $\mu^+ \mu^-$ + c

Physics analysis reported in Section 11.10.3 of the Technical Proposal. Specific thresholds for the leptons are not given in the T.P.

physics μ + μ + b50 + j50 + j50 + M(Z)

LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz
LVL3	mu10 + mu10	4 Hz
LVL3F	mu20I + mu20I + b30	0.1 Hz

LVL1	MU6	23 000 Hz

LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I+ b40 + j40 + j40	0.1 Hz

A.3. SUSY Particles

A.3.1. General SUSY studies

SUSY $\rightarrow$ multi-jets + missing-E_t

Physics analysis reported in ATLAS internal note PHYS-NO-57 [49].

physics j200 + j200 + j200 + j100 + me300

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j100 + j100 + j50 + j50	16 Hz
LVL3	j100 + j100 + j100 + j100	2 Hz
LVL3F	j200 + j200 + j100 + j100	1 Hz
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz
LVL1	ME60	70 Hz
LVL2	me90	3 Hz
LVL3	me100	0.8 Hz
LVL3F	me120	0.1 Hz

SUSY $\rightarrow$ multijets + missing-E_t

Physics analyses presented by F. Paige at the LHCC SUSY Workshop [7], [50].

physics j100 + j50 + j50 + j50 + me100

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

physics Meff = missing-E_t + sum(E_t)

LVL1	ME60	70 Hz
LVL2	te1000	1 Hz
LVL3	te1000	0.5 Hz
LVL3F	te1500	0.1 Hz
LVL1	SE700	20 Hz
LVL2	te2000	1 Hz
LVL3	te1000	0.5 Hz
LVL3F	te1500	0.1 Hz

NOTE: TE signifies total-E_t = scalar-E_t + missing-E_t

SUSY $\rightarrow$ e + multi-jets + missing-E_t

Physics analysis reported by G. Polesello, ATLAS SUSY Workshop, Stockholm, January 1996 [6].

physics	e20 + j100 + j100 + me100	
LVL1	EM20I	11 980 Hz
LVL2	e20I + j40 + j40	6 Hz
LVL3	e20I + j40 + j40	3 Hz
LVL3F	e20I + j100 + j100 + me40	0.1 Hz

SUSY $\rightarrow$ μ + multi-jets + missing-E_t

Physics analysis reported by G. Polesello, ATLAS SUSY Workshop, Stockholm, January 1996 [6].

Physics	mu20 + j100 + j100 + me100	
LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + me20	12 Hz
LVL3F	mu20I + j40 + j40 + me40	0.1 Hz
LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + j30 + j30	2 Hz
LVL3F	mu20I + j40 + j40 + me40	0.1 Hz

SUSY $\rightarrow$ $e^+ e^+$ + multi-jets + missing-E_t

Physics analysis reported in Section 11.12.3 of the Technical Proposal [4].

physics	e20 + e20 + j70 + j70 + j70 + j70 + me120	
LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	*no entry*	
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + e10I + e10I	5 Hz
LVL3	j50 + j50 + j50 + e10I + e10I	5 Hz
LVL3F	*no entry*	
LVL1	ME40 + J50	820 Hz
LVL2	me60 + j50 + j50 + e10I	3 Hz
LVL3	me80 + j50 + j50 + e10I	0.1 Hz
LVL3F	me80 + j50 + j50 + e10I	0.1 Hz

SUSY $\rightarrow$ $\mu^+ \mu^+$ + multi-jets + missing-E_t

Physics analysis reported in Section 11.12.3 of the Technical Proposal [4].

physics	mu20 + mu20 + j70 + j70 + j70 + j70 + me120	
LVL1	ME40 + J50	820 Hz
LVL2	me60 + j50 + j50 + mu6	3 Hz

LVL3	me80 + j50 + j50 + mu6	0.1 Hz
LVL3F	me80 + j50 + j50 + mu6	0.1 Hz

SUSY $\rightarrow$ $e^+ \mu^+$ + multi-jets + missing-E_t

Physics analysis reported in Section 11.12.3 of the Technical Proposal [4].

physics mu20 + e20 + j70 + j70 + j70 + j70 + me120

LVL1	MU6	23 000 Hz
LVL3	mu10I + e10I	8 Hz
LVL3	mu10I + e10I	2 Hz
LVL3F	mu15I + e15I	0.1 Hz
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + mu6	3 Hz
LVL3	j50 + j50 + j50 + mu6	1.5 Hz
LVL3F	j50 + j50 + j50 + mu6 + e10I	0.1 Hz

SUSY $\rightarrow$ e + e + e + missing-E_t

Physics analysis reported in ATLAS internal note PHYS-NO-61 [51].

physics e20 + e20 + e10 + me10 + ...

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + e7I	0.2 Hz

SUSY $\rightarrow$ $\mu + \mu + \mu$ + missing-E_t

Physics analysis reported in ATLAS internal note PHYS-NO-61 [51].

physics mu20 + mu20 + mu10 + me10 + ...

LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + mu6I	0.1 Hz

SUSY $\rightarrow$ e + e + μ + missing-E_t

Physics analysis reported in ATLAS internal note PHYS-NO-61 [51].

physics e20 + e20 + mu10 + me10 + ...

LVL1	MU6	23 000 Hz
LVL2	mu6 + e10I + e10I	1 Hz
LVL3	mu6 + e10I + e10I	0.3 Hz
LVL3F	mu6I + e10I + e10I	0.2 Hz

SUSY $\rightarrow$ $\mu + \mu$ + e + missing-E_t

Physics analysis reported in ATLAS internal note PHYS-NO-61 [51].
A trigger item should be added for mu20 + mu20 + e10 + me10 + ...

physics	e20 + mu20 + mu10 + me10 + ...	
LVL1	MU6	23 000 Hz
LVL2	mu6 + mu6 + e10I	1 Hz
LVL3	mu6 + mu6 + e10I	0.3 Hz
LVL3F	mu6I + mu6I + e10I	0.1 Hz

SUSY $\rightarrow$ neutralino$_1$ neutralino$_2$ $\rightarrow$ γ + missing-E$_t$

Physics analysis reported by K. Hultqvist, ATLAS SUSY Workshop, Stockholm, January 1996 [6].

LVL1	EM20I	11 980 Hz
LVL2	g40I + me40	4 Hz
LVL3	g40I + me40	0.4 Hz
LVL3F	g40I + me40	0.4 Hz

neutralino$_1$ neutralino$_1$ $\rightarrow$ gamma Gravitino + gamma Gravitino

Physics analyses presented by G. Kane at SUSY96 [52].

physics	gamma gamma + missing-E$_t$	
LVL1	EM20I	11 980 Hz
LVL2	g40I + me40	4 Hz
LVL3	g40I + me40	0.4 Hz
LVL3F	g40I + me40	0.4 Hz
LVL1	EM10I + EM10I	9 330 Hz
LVL2	g20I + g20I	2 Hz
LVL3	g20I + g20I	0.5 Hz
LVL3F	g20I + g20I + me40	0.1 Hz

SUSY $\rightarrow$ squark$_R$ squark$_R$ $\rightarrow$ j j + missing-E$_t$

Physics analysis reported by E. Richter-Was, ATLAS LVL2 Trigger Workshop, Cracow, April 1996 [53].

physics	j100 + j100 + me100	
LVL1	J100	2 290 Hz
LVL2	j100 + j100 + me80	2 Hz
LVL3	j100 + j100 + me90	1 Hz
LVL3F	j100 + j100 + me100	0.3 Hz

SUSY $\rightarrow$ h^0 $\rightarrow$ b b

Physics analysis reported in ATLAS internal note PHYS-NO-42 [54].

physics	b50 + b50 + j50 + j50 + j50 + j50 + me150	
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + j50 + j50 + j50	5 Hz

LVL3	j50 + j50 + j50 + j50 + j50 + j50	5 Hz
LVL3F	*no entry*	

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	b50 + b50 + j50 + j50 + j50	2 Hz
LVL3	b50 + b50 + j50 + j50 + j50	0.5 Hz
LVL3F	*no entry*	

SUSY $\rightarrow$ H^+ $\rightarrow$ t b $\rightarrow$ W + b b $\rightarrow$ j j + b b

Physics analysis reported in ATLAS internal note PHYS-NO-35 [55].

physics	b50 + b50 + j50 + j50 + j50 + me120	

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	b50 + b50 + j50 + j50 + j50	2 Hz
LVL3	b50 + b50 + j50 + j50 + j50	0.5 Hz
LVL3F	*no entry*	

A.3.2. SUSY points #1 and #2

Physics analyses for SUSY points #1 and #2 were presented by G. Polesello at the LHCC SUSY Workshop [7], [56]. The SUGRA parameters are $m_0 = m_{1/2}$ = 400 GeV, A = 0 GeV, sign(μ) = +, with tan β = 2 for point #1 and tan β = 10 for point #2.

$squark_R$ $squark_L$ $\rightarrow$ q q h + missing-E_t $\rightarrow$ q q b bbar + missing-E_t

physics	b50 + b50 + j100 + j100 + me300	

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

LVL1	J100	2 290 Hz
LVL2	j100 + j100 + me80	2 Hz
LVL3	j100 + j100 + me90	1 Hz
LVL3F	j100 + j100 + me100	0.3 Hz

LVL1	J100	2 290 Hz
LVL2	j100 + j100 + j50 + j50	16 Hz
LVL3	j100 + j100 + b50 + b50	0.1 Hz
LVL3F	j100 + j100 + b50 + b50	0.1 Hz

$squark_R$ $squark_R$ $\rightarrow$ q q + missing-E_t

physics	j100 + j100 + me400	

LVL1	J100	2 290 Hz
LVL2	j100 + j100 + me80	2 Hz

LVL3	j100 + j100 + me90	1 Hz
LVL3F	j100 + j100 + me100	0.3 Hz

LVL1	ME40 + J50	820 Hz
LVL2	j100 + j100 + me80	2 Hz
LVL3	j100 + j100 + me90	1 Hz
LVL3F	j100 + j100 + me100	0.3 Hz

LVL1	ME60	70 Hz
LVL2	me90	3 Hz
LVL3	me100	0.8 Hz
LVL3F	me120	0.1 Hz

SUSY $\rightarrow$ b bbar b bbar + missing-E_t

physics b50 + b50 + b50 + b50 + me300

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	b50 + b50 + b50	1 Hz
LVL3	b50 + b50 + b50	0.1 Hz
LVL3F	b50 + b50 + b50	0.1 Hz

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

LVL1	ME40 + J50	820 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

gluino $\rightarrow$ stop top

physics SUSY t tbar trigger

A.3.3. SUSY point #3

Physics analyses for SUSY point #3 were presented by F. Gianotti at the LHCC SUSY Workshop [7], [57]. The SUGRA parameters are m_0 = 200 GeV, $m_{1/2}$ = 100 GeV, A = 0 GeV, sign(μ) = –, tan β = 2.

gluino $\rightarrow$ sbottom bbar $\rightarrow$ b bbar $neutralino_2$ $\rightarrow$ b bbar l^+ l^- $neutralino_1$

physics b15 + b15 + e10 + e10

LVL1	EM10I + EM10I	9 330 Hz
LVL2	$e10I_\beta$ + $e10I_\beta$ + b15 + b15	10 Hz
LVL3	$e10I_\beta$ + $e10I_\beta$ + b15 + b15	3 Hz
LVL3F	$e10I_\beta$ + $e10I_\beta$ + b15 + b15	3 Hz

physics b15 + b15 + mu10 + mu10

LVL1	MU6	23 000 Hz

LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + b15 + b15	0.2 Hz

$squark_L \rightarrow$ quark $neutralino_2 \rightarrow$ quark $l^+ l^-$ $neutralino_1$

physics	j125 + e10 + e10	
LVL1	J100	2 290 Hz
LVL2	j100 + e10I + e10I	1 Hz
LVL3	j100 + e10I + e10I	0.3 Hz
LVL3F	j100 + e10I + e10I + me80	0.1 Hz
physics	j125 + mu10 + mu10	
LVL1	MU6	23 000 Hz
LVL2	j100 + mu6 + mu6	1 Hz
LVL3	j100 + mu6 + mu6	0.3 Hz
LVL3F	j100 + mu6 + mu6	0.3 Hz

A.3.4. SUSY point #4

Physics analyses for SUSY point #4 were presented by F. Gianotti at the LHCC SUSY Workshop [7], [58]. The SUGRA parameters are m_0 = 800 GeV, $m_{1/2}$ = 200 GeV, A = 0 GeV, sign(μ) = +, tan β = 10.

gluino $\rightarrow$ q qbar $neutralino_2 \rightarrow$ q qbar $l^+ l^-$ $neutralino_1$

physics	e20 + e10 + j50 + j50 + j50 + me200	
LVL1	J50 + J50 + J50	1 310 Hz
LVL3	j50 + j50 + j50 + e10I	20 Hz
LVL3	j50 + j50 + j50 + e10I + e10I	0.2 Hz
LVL3F	j50 + j50 + j50 + e10I + e10I	0.2 Hz
LVL1	ME40 + J50	820 Hz
LVL2	me60 + j50 + j50 + e10I	3 Hz
LVL3	me80 + j50 + j50 + e10I	0.1 Hz
LVL3F	me80 + j50 + j50 + e10I	0.1 Hz
physics	mu20 + mu10 + j50 + j50 + j50 + me200	
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + mu6	3 Hz
LVL3	j50 + j50 + j50 + mu6	1.5 Hz
LVL3F	j50 + j50 + j50 + mu6 + mu6	0.1 Hz
LVL1	ME40 + J50	820 Hz
LVL2	me60 + j50 + j50 + mu6	3 Hz
LVL3	me80 + j50 + j50 + mu6	0.1 Hz
LVL3F	me80 + j50 + j50 + mu6	0.1 Hz
background	mu20 + e10 + j50 + j50 + j50 + me200	
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + mu6	3 Hz
LVL3	j50 + j50 + j50 + mu6	1.5 Hz

LVL3F	j50 + j50 + j50 + mu6 + e10I	0.1 Hz

$chargino_2 \rightarrow Z + chargino_1 \rightarrow Z + lepton\ nu + neutralino_1$

physics	e20 + e20 + e10 + me100 + MZ	
LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + e7I	0.2 Hz
LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + me40	0.1 Hz
physics	e20 + e20 + mu10 + me100 + MZ	
LVL1	MU6	23 000 Hz
LVL2	mu6 + e10I + e10I	1 Hz
LVL3	mu6 + e10I + e10I	0.3 Hz
LVL3F	mu6I + e10I + e10I	0.2 Hz
physics	mu20 + mu20 + mu10 + me100 + MZ	
LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + mu6I	0.1 Hz
physics	mu20 + mu20 + e10 + me100 + MZ	
LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu10I + mu10I + e7I	0.3 Hz

Plus inclusive Z triggers

gluino gluino $\rightarrow$ q qbar q qbar $l^+ l^- l^\pm$

physics	e20 + e10 + e10 + j40 + j40 + j40 + j40	
LVL1	EM20I	11 980 Hz
LVL2	e20I + j40 + j40	6 Hz
LVL3	e20I + j40 + j40	3 Hz
LVL3F	e20I + j40 + j40 + j40 + j40	0.1 Hz
LVL1	EM20I	11 980 Hz
LVL2	e10I + e10I + e10I	1 Hz
LVL3	e10I + e10I + e10I	0.3 Hz
LVL3F	e20I + e10I + e10I	0.1 Hz
physics	e20 + e10 + mu10 + j40 + j40 + j40 + j40	
LVL1	MU6	23 000 Hz
LVL2	mu6 + e10I + e10I	1 Hz
LVL3	mu6 + e10I + e10I	0.3 Hz
LVL3F	mu6I + e10I + e10I	0.2 Hz

physics	mu20 + mu10 + mu10 + j40 + j40 + j40 + j40	
LVL1	MU6	23 000 Hz
LVL2	mu10I + j40 + j40 + j40	1 Hz
LVL3	mu10I + j40 + j40 + j40 + j40	0.3 Hz
LVL3F	mu10I + j40 + j40 + j40 + j40	0.3 Hz
LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + mu6I	0.1 Hz
physics	mu20 + mu10 + e10 + j40 + j40 + j40 + j40	
LVL1	MU6	23 000 Hz
LVL2	mu10I + j40 + j40 + j40	1 Hz
LVL3	mu10I + j40 + j40 + j40 + j40	0.3 Hz
LVL3F	mu10I + j40 + j40 + j40 + j40	0.3 Hz
background	e20 + mu10 + mu10 + j40 + j40 + j40 + j40	
LVL1	MU6	23 000 Hz
LVL2	mu6 + mu6 + e10I	1 Hz
LVL3	mu6 + mu6 + e10I	0.3 Hz
LVL3F	mu6I + mu6I + e10I	0.1 Hz
background	mu20 + e10 + e10 + j40 + j40 + j40 + j40	
LVL1	MU6	23 000 Hz
LVL2	mu6 + e10I + e10I	1 Hz
LVL3	mu6 + e10I + e10I	0.3 Hz
LVL3F	mu6I + e10I + e10I	0.2 Hz

squark $\rightarrow$ q gluino $\rightarrow$ q q qbar q qbar + neutralino_1

physics	j100 + j100 + j100 + j100 + j100 + me300	
LVL1	J100	2 290 Hz
LVL2	j100 + j100 + me80	2 Hz
LVL3	j100 + j100 + me90	1 Hz
LVL3F	j100 + j100 + me100	0.3 Hz
LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j100 + j100 + j50 + j50	16 Hz
LVL3	j100 + j100 + j100 + j100	2 Hz
LVL3F	*no entry*	

$\text{neutralino}_{3,4} \rightarrow$ W + $\text{chargino}_1 \rightarrow$ l^+ nu + l^- nu + neutralino_1

physics	e20 + e10 + me100	
LVL1	EM20I	11 980 Hz
LVL2	e20I + e10I	2 Hz
LVL3	e20I + e10I	0.5 Hz
LVL3F	*no entry*	
physics	mu20 + mu10 + me100	

LVL1	MU6	23 000 Hz
LVL2	mu15I + mu6	1 Hz
LVL3	mu15I + mu6 + me40	0.1 Hz
LVL3F	mu15I + mu6 + me40	0.1 Hz

LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + me40	0.5 Hz

physics e20 + mu10 + me100

LVL1	EM20I	11 980 Hz
LVL2	e20I_β + me20	50 Hz
LVL3	e20I_β + me20	25 Hz
LVL3F	*no entry*	

physics mu20 + e10 + me100

LVL1	MU6	23 000 Hz
LVL2	mu10I + e10I	8 Hz
LVL3	mu10I + e10I	2 Hz
LVL3F	mu15I + e10I + me40	0.1 Hz

A.3.5. SUSY point #5

Physics analyses for SUSY point #5 were presented by G. Polesello at the LHCC SUSY Workshop [7], [59]. The SUGRA parameters are m_0 = 100 GeV, $m_{1/2}$ = 300 GeV, A = 300 GeV, sign(μ) = +, tan β = 2.1. This point is in the "cosmologically favoured" region of phase space.

selectron$_L$ selectron$_L$ $\rightarrow$ e + e + missing-E_t

physics Pt(e+ e-) > 90 GeV

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + me40	0.1 Hz

slepton$_L$ slepton$_L$ $\rightarrow$ mu + mu + missing-E_t

physics Pt(mu+ mu-) > 90 GeV

LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + me40	0.5 Hz

background Pt(e mu) > 90 GeV

LVL1	MU6	23 000 Hz
LVL2	mu6I + e15I	8 Hz
LVL3	mu6I + e15I + me40	0.3 Hz
LVL3F	mu6I + e15I + me40	0.3 Hz

SUSY $\rightarrow$ t tbar + missing-E_t $\rightarrow$ b bbar + 4 jets + missing-E_t

physics	b + b + j + j + j + j + me300 + M(jj)=MW + M(jj)=MW	
LVL1	ME60	70 Hz
LVL2	me90	3 Hz
LVL3	me100	0.8 Hz
LVL3F	me120	0.1 Hz

stop stop $\rightarrow$ top top + missing-E_t

physics SUSY t tbar trigger

$squark_L$ $\rightarrow$ q + $neutralino_2$ $\rightarrow$ $slepton_R$ + $l^{\pm}$ + q $\rightarrow$ $l^+ l^-$ q + missing-E_t

physics	e10 + e10 + j150 + j150 + me300	
LVL1	J100	2 290 Hz
LVL2	j100 + e10I + e10I	1 Hz
LVL3	j100 + e10I + e10I	0.3 Hz
LVL3F	j100 + e10I + e10I + me80	0.1 Hz
LVL1	J100	2 290 Hz
LVL2	j100 + j100 + me80	2 Hz
LVL3	j100 + j100 + me90	1 Hz
LVL3F	j100 + j100 + me100	0.3 Hz
physics	mu10 + mu10 + j150 + j150 + me300	
LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + me40	0.5 Hz
LVL1	MU6	23 000 Hz
LVL2	mu6I + j100 + j100	10 Hz
LVL3	mu6I + j100 + j100 + me80	0.1 Hz
LVL3F	mu6I + j100 + j100 + me80	0.1 Hz
background	mu10 + e10 + j150 + j150 + me300	
LVL1	MU6	23 000 Hz
LVL2	mu6I + j100 + j100	10 Hz
LVL3	mu6I + j100 + j100 + me80	0.1 Hz
LVL3F	mu6I + j100 + j100 + me80	0.1 Hz

A.3.6. SUSY Point #6.

Physics analyses for SUSY point #6 were presented by F. Paige [60].
The SUGRA parameters are $m_0 = m_{1/2}$ = 200 GeV, A = 0, sign(μ) = –, tan β = 45.

$neutalino_2$ + $neutalino_2$ $\rightarrow$ stau tau + stau tau $\rightarrow$ $\tau^+ \tau^- \tau^+ \tau^-$ + missing-E_t

physics	j100 + j50 + j50 + j50 + me100 + Meff > 500 GeV + ...	
LVL1	J50 + J50 + J50	1 310 Hz

LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

LVL1	ME40 + J50	820 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

gluino gluino → bino b + bino b → b b b b + missing-E_t

physics j100 + j50 + j50 + j50 + me100 + Meff > 500 GeV + ...

LVL1	J50 + J50 + J50	1 310 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

LVL1	ME40 + J50	820 Hz
LVL2	j50 + j50 + j50 + me60	8 Hz
LVL3	j50 + j50 + j50 + me80	0.4 Hz
LVL3F	j50 + j50 + j50 + me80	0.4 Hz

A.3.7. R-parity Violating SUSY Decays

neutralino neutralino → c d s + cds → multijets (R-parity violating neutralino decay)

Physics analysis presented by J. Soderqvist at the ATLAS Physics Meeting, 18 November 1997 [61].

physics 2 * j200 + 6 * j20 (with se1000)

LVL1	J100	2 290 Hz
LVL2	j150 + j150 + se800	1 Hz
LVL3	j150 + j150 + se800	1 Hz
LVL3F	j200 + j200 + se800	0.3 Hz

LVL1	SE700	20 Hz
LVL2	te1000	1 Hz
LVL3	te1000	0.5 Hz
LVL3	te1500	0.1 Hz

Physics analysis presented by J. Soderqvist at the ATLAS Physics Working Group Meeting, 5 March 1998 [62].

physics mu20 + 8 * j17.5

LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu20I + 6 * j15	1 Hz
LVL3F	mu20I + 8 * j15	0.3 Hz

physics e20 + 8 * j17.5

LVL1	EM20I	11 980 Hz
LVL2	e20I + 6 * j15	12 Hz
LVL3	e20I + 6 * j15	6 Hz

LVL3F	e20I + 8 * j15		1.5 Hz

Long-lived SUSY particles

Long-lived heavy charged particles look like very-high P_t muons.
The SUSY particles are still prodeced by pairs.

LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz
LVL3	mu10 + mu10	4 Hz
LVL3F	mu40 + mu40	0.1 Hz

A.4. Heavy Vector Bosons

$Z' \rightarrow j\ j$

Physics analysis reported in ATLAS internal note PHYS-NO-10 [63].

physics j150 + j150

LVL1	J100		2 290 Hz
LVL2	j150 + j150	prescale/100	1 Hz
LVL3	j150 + j150	prescale/100	1 Hz
LVL3F	*no entry*		

LVL1	J100	2 290 Hz
LVL2	j400 + j400	1 Hz
LVL3	j400 + j400	1 Hz
LVL3F	j500 + j500	0.3 Hz

$Z' \rightarrow e^+ e^-$

Physics cuts for the dilepton decays are taken to be identical to the cuts proposed for dijet events in ATLAS internal note PHYS-NO-10 [63].

physics e150 + e150

LVL1	EM80	520 Hz
LVL2	e80 + e80	1 Hz
LVL3	e80 + e80	0.1 Hz
LVL3F	e80 + e80	0.1 Hz

$Z' \rightarrow \mu^+ \mu^-$

Physics cuts for the dilepton decays are taken to be identical to the cuts proposed for dijet events in ATLAS internal note PHYS-NO-10 [63].

physics mu150 + mu150

LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz
LVL3	mu10 + mu10	4 Hz
LVL3F	mu40 + mu40	0.1 Hz

$Z' \rightarrow \tau^+ \tau^-$

Physics cuts for the dilepton decays are taken to be identical to the cuts proposed for dijet events in ATLAS internal note PHYS-NO-10 [63].

physics	tau150 + tau150	
LVL1	TAU80I	2 530 Hz
LVL2	tau80I + tau80I	1 Hz
LVL3	tau80I + tau80I	0.3 Hz
LVL3F	tau80I + tau80I	0.3 Hz

W' $\rightarrow$ $e^{\pm}\,\nu$

Physics analysis reported in ATLAS internal note PHYS-NO-59 [64].

physics	e200 + me200	
LVL1	EM80	520 Hz
LVL2	e80 + me40	2 Hz
LVL3	e80 + me40	0.2 Hz
LVL3F	e80 + me40	0.2 Hz

W' $\rightarrow$ $\mu^{\pm}\,\nu$

Physics cuts are taken to be identical to the cuts proposed for the electronic decays in ATLAS internal note PHYS-NO-59 [64].

physics	mu200 + me200	
LVL1	MU6	23 000 Hz
LVL2	mu60	2 Hz
LVL3	mu60	1 Hz
LVL3F	mu60 + me40	0.3 Hz

W' $\rightarrow$ $\tau^{\pm}\,\nu$

Physics cuts are taken to be identical to the cuts proposed for the electronic decays in ATLAS internal note PHYS-NO-59 [64].

physics	tau200 + me200	
LVL1	TAU150	1 730 Hz
LVL2	tau150 + me80	1 Hz
LVL3	tau150 + me80	0.3 Hz
LVL3F	tau150 + me80	0.3 Hz
LVL1	ME60	70 Hz
LVL2	me90	3 Hz
LVL3	me100	0.8 Hz
LVL3F	me120	0.1 Hz

A.5. Leptoquarks

quark gluon $\rightarrow$ lepton + LQ $\rightarrow$ lepton + lepton-jet

Physics analysis reported in Section 11.13.2 of the Technical Proposal. The cuts used in the physics analysis are for M = 1 TeV, but the search should start at 300 GeV.

physics	e300 + e300 + j300 + M(LQ) > 120	
LVL1	EM80	520 Hz
LVL2	e80 + j100	7 Hz
LVL3	e80 + j100	3 Hz
LVL3F	e80 + e60 + j100	0.1 Hz

gluon gluon $\rightarrow$ LQ + LQ $\rightarrow$ lepton-jet + lepton-jet

Physics analysis reported in Section 11.13.2 of the Technical Proposal [4].

physics	e200 + e200 + j200 + j200	
LVL1	EM80	520 Hz
LVL2	e80 + j100	7 Hz
LVL3	e80 + j100	3 Hz
LVL3F	e80 + e60 + j100	0.1 Hz

A.6. Compositeness

quark compositeness : single jets

Physics analysis reported in Section 11.13.3.1 of the Technical Proposal [4].

physics	j300		
LVL1	J100		2 290 Hz
LVL2	j200	prescale/100	1 Hz
LVL3	j200	prescale/100	1 Hz
LVL3F	*no entry*		
LVL1	J100		2 290 Hz
LVL2	j500		1 Hz
LVL3	j500		1 Hz
LVL3F	j600		0.3 Hz

lepton compositeness : di-leptons

Physics analysis reported in Section 11.13.3.2 of the Technical Proposal [4].

physics	e400 + e400	
LVL1	EM80	520 Hz
LVL2	e80 + e80	1 Hz
LVL3	e80 + e80	0.1 Hz
LVL3F	e80 + e80	0.1 Hz

A.7. Gauge Boson Pair Production

W $\gamma \rightarrow$ e $\nu + \gamma$

Physics analysis reported in Section 11.13.4.1 of the Technical Proposal [4].

The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics	e40 + g100	
LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + g15I	12 Hz
LVL3	e15I + g15I	4 Hz
LVL3F	e20I + g60I	0.2 Hz

$W \gamma \rightarrow \mu \nu + \gamma$

Physics analysis reported in Section 11.13.4.1 of the Technical Proposal [4].
The physics cuts shown are for high luminosity (10^{34} cm^{-2} s^{-1}).

physics	mu40 + g100	
LVL1	MU6	23 000 Hz
LVL2	mu15 + g20I	1 Hz
LVL3	mu20 + g20I	0.2 Hz
LVL3F	mu20 + g40I	0.1 Hz

$W Z \rightarrow e \nu + e^+ e^-$

Physics analysis reported in Section 11.13.4.2 of the Technical Proposal [4].

physics	e25I + e25I + e25I + M(Z) + M_T(W)	
LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I + e7I	0.2 Hz

$W Z \rightarrow \mu \nu + \mu^+ \mu^-$

Physics analysis reported in Section 11.13.4.2 of the Technical Proposal [4].

physics	mu25I + mu25I + mu25I + M(Z) + M_T(W)	
LVL1	MU6	23 000 Hz
LVL2	mu6I + mu6I	9 Hz
LVL3	mu6I + mu6I	5 Hz
LVL3F	mu6I + mu6I + mu6I	0.1 Hz

$W Z \rightarrow e \nu + \mu^+ \mu^-$

Physics analysis reported in Section 11.13.4.2 of the Technical Proposal [4].

physics	e25I + mu25I + mu25I + M(Z) + M_T(W)	
LVL1	MU6	23 000 Hz
LVL2	mu6 + mu6 + e10I	1 Hz
LVL3	mu6 + mu6 + e10I	0.3 Hz
LVL3F	mu6I + mu6I + e10I	0.1 Hz

$W Z \rightarrow \mu \nu + e^+ e^-$

Physics analysis reported in Section 11.13.4.2 of the Technical Proposal [4].

physics	mu25I + e25I + e25I + M(Z) + M(W)	
LVL1	MU6	23 000 Hz
LVL2	mu6 + e10I + e10I	1 Hz
LVL3	mu6 + e10I + e10I	0.3 Hz
LVL3F	mu6I + e10I + e10I	0.2 Hz

A.8. B-Physics

Physics analyses for the B physics channels were reported in Section 11.11.2 of the Technical Proposal. Recent progress on trigger rates was reported by M. Smizanska in Ref.[15]. The rates listed in this second version of the physics catalog have been increased to account for non-B background. All of these rates should be updated using the more recent results from M. Smizanska [16].

$\mu + B \rightarrow \mu + J/\psi + X \rightarrow \mu + e^+ e^- + X$

physics	mu6 + e1 + e1 + M(J/ψ) + B-vtx	
LVL1	MU6	23 000 Hz
LVL2	mu6 + e1 + e1 + M(J/ψ)	50 Hz
LVL3	mu6 + e1 + e1 + M(J/ψ) + Bvtx	30 Hz
LVL3F	mu6 + e1 + e1 + M(J/ψ) + Bvtx	10 Hz

$\mu + B \rightarrow \mu + J/\psi + X \rightarrow \mu + \mu^+ \mu^- + X$

physics	mu6 + mu5 + mu3 + M(J/ψ) + B-vtx	
LVL1	MU6	23 000 Hz
LVL2	mu6 + mu5 + mu3 + M(J/ψ)	20 Hz
LVL3	mu6 + mu5 + mu3 + M(J/ψ)	20 Hz
LVL3F	mu6 + mu5 + mu3 + M(J/ψ)	6 Hz

$e + B \rightarrow e + J/\psi + X \rightarrow e + \mu^+ \mu^- + X$

physics	e6 + mu6 + mu3 + M(J/ψ) + B-vtx	
LVL1	MU6	23 000 Hz
LVL2	mu6 + e5 + mu3 + M(J/ψ)	10 Hz
LVL3	mu6 + e5 + mu3 + M(J/ψ)	10 Hz
LVL3F	mu6 + e5 + mu3 + M(J/ψ)	2 Hz

$\mu + B_d \rightarrow \mu + \pi^+ \pi^-$

physics	mu6 + h6 + h6 + M(B_d) + B-vtx + ...	
LVL1	MU6	23 000 Hz
LVL2	mu6 + t5 + t5 + M(B)	80 Hz
LVL3	mu6 + t6 + t6 + tt15 + M(B) + B-vtx	10 Hz

LVL3F	mu6 + t6 + t6 + tt15 + M(B) + B-vtx	2 Hz

$\mu + B_S \rightarrow \mu + D_S^- \pi^+ \rightarrow \mu + \phi \pi^- \pi^+ \rightarrow \mu + K^+ K^- \pi^- \pi^+$

physics	mu6 + h1.5 + h1.5 + h1.0 + $M(\phi^0)$ + $M(D_s)$	
LVL1	MU6	23 000 Hz
LVL2	mu6 + t1.5 + t1.5 + t1.5 + $M(\phi^0)$ + $M(D_s)$	100 Hz
LVL3	mu6 + t1.5 + t1.5 + t1.5 + $M(\phi^0)$ + $M(D_s)$ + B-vtx	20 Hz
LVL3F	mu6 + t1.5 + t1.5 + t1 + $M(\phi)$ + M(D) + M(B) + B-vtx	2 Hz

$B \rightarrow \mu^+ \mu^-$

physics	mu6 + mu5 + M(B) + B-vtx	
LVL1	MU6	23 000 Hz
LVL2	mu6 + mu5 + M(B)	50 Hz
LVL3	mu6 + mu5 + M(B) + B-vtx	10 Hz
LVL3F	mu6 + mu5 + M(B) + B-vtx	2 Hz

A.9. Inclusive Triggers

A.9.1. Inclusive W and Z Leptonic Decays

$Z \rightarrow e^+ e^-$

LVL1	EM10I + EM10I	9 330 Hz
LVL2	e15I + e15I	4 Hz
LVL3	e15I + e15I	2 Hz
LVL3F	e15I + e15I	2 Hz

$Z \rightarrow \mu^+ \mu^-$

LVL1	MU6	23 000 Hz
LVL2	mu10 + mu10	13 Hz
LVL3	mu10 + mu10	4 Hz
LVL3F	mu10I + mu10I	1.8 Hz

$Z \rightarrow \tau^+ \tau^- \rightarrow \mu$ + hadrons

HCAL calibration presented by S. Resconi at the ATLAS Physics Meeting, 18 November 1997 [48].

physics	HCAL calibration	
LVL1	MU6	23 000 Hz
LVL2	mu15I + tau20I	3 Hz
LVL3	mu15I + tau30I	1 Hz
LVL3F	mu20I + tau40I	0.1 Hz

$Z \rightarrow \tau^+ \tau^- \rightarrow e$ + hadrons

HCAL calibration presented by S. Resconi at the ATLAS Physics Meeting, 18 November 1997 [48].

physics	HCAL calibration	
LVL1	EM20I	11 980 Hz
LVL2	e20I + tau40I	4 Hz
LVL3	e20I + tau40I	1 Hz
LVL3F	e20I + tau40I	1 Hz

$W \rightarrow e^{\pm} \nu$

Physics analysis presented by F. Gianotti at the ATLAS Physics Meeting, 18 November 1997 [61].

physics	e25 + me25	W mass	
LVL1	EM20I		11 980 Hz
LVL2	$e20I_{\beta}$ + me20		50 Hz
LVL3	$e20I_{\beta}$ + me20		25 Hz
LVL3F	$e20I_{\beta}$ + me20		25 Hz

$W \rightarrow \mu^{\pm} \nu$

Physics analysis presented by F. Gianotti at the ATLAS Physics Meeting, 18 November 1997 [61].

physics	mu25 + me25	W mass	
LVL1	MU6		23 000 Hz
LVL2	mu20I		40 Hz
LVL3	mu20I + me20		12 Hz
LVL3F	mu20I + me20		12 Hz

A.9.2 Inclusive Single-Particle Triggers

Single non-isolated muon

LVL1	MU6	23 000 Hz
LVL2	mu60	2 Hz
LVL3	mu60	1 Hz
LVL3F	*no entry*	

Single isolated muon

LVL1	MU6	23 000 Hz
LVL2	mu20I	40 Hz
LVL3	mu40I	4 Hz
LVL3F	*no entry*	

Single non-isolated electron

LVL1	EM80	520 Hz
LVL2	e100	10 Hz
LVL3	e200	0.3 Hz

LVL3F	*no entry*	

Single isolated electron

LVL1	EM20I	11 980 Hz
LVL2	e40I	7 Hz
LVL3	e40I	5 Hz
LVL3F	*no entry*	

Single isolated gamma

LVL1	EM20I	11 980 Hz
LVL2	g80I	3 Hz
LVL3	g100I	1 Hz
LVL3F	*no entry*	

Single isolated tau (1-prong and 3-prong decays)

LVL1	TAU80I	2 530 Hz
LVL2	tau200I	5 Hz
LVL3	tau200I	2.5 Hz
LVL3F	*no entry*	

Single jet

LVL1	J100	2 290 Hz
LVL2	j500	1 Hz
LVL3	j500	1 Hz
LVL3F	j600	0.3 Hz

Single b-jet

LVL1	J100	2 290 Hz
LVL2	b300	1 Hz
LVL3	b300	0.5 Hz
LVL3F	*no entry*	

Missing-E_t

LVL1	ME60	70 Hz
LVL2	me90	3 Hz
LVL3	me100	0.8 Hz
LVL3F	me120	0.1 Hz

Total-E_t

LVL1	SE700	20 Hz
LVL2	te1000	1 Hz
LVL3	te1000	0.5 Hz
LVL3	te1500	0.1 Hz

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