ATLAS Triggering on SUSY in 2012

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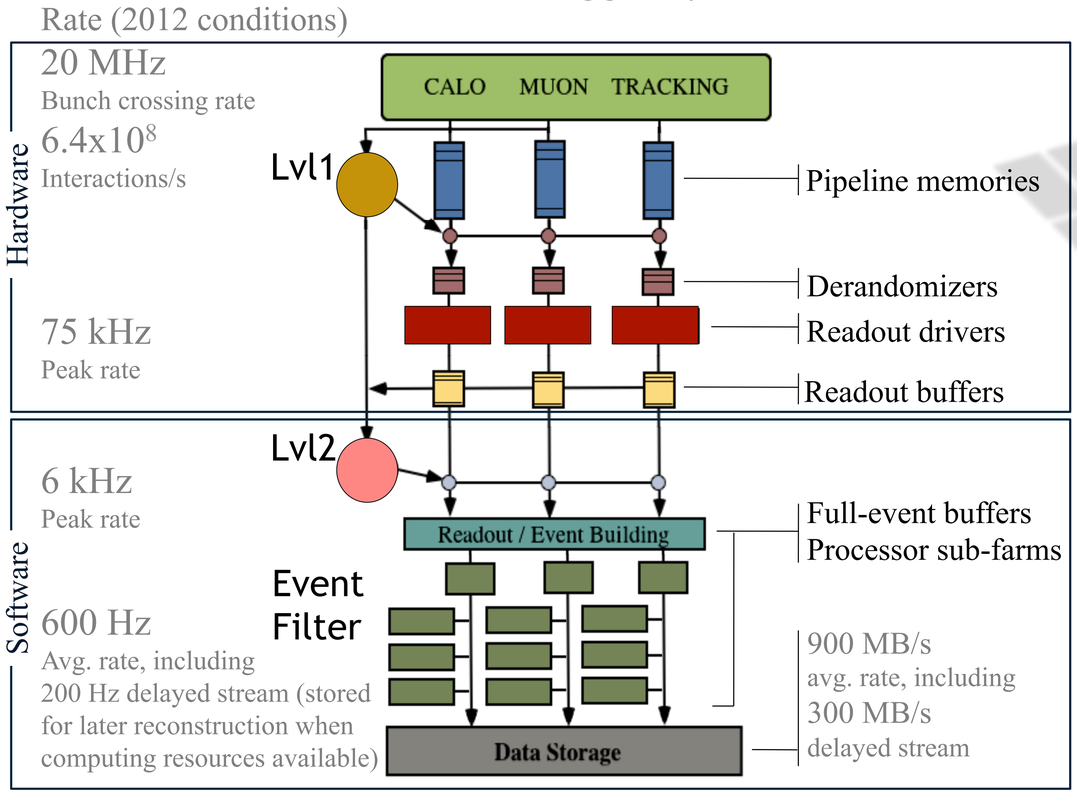
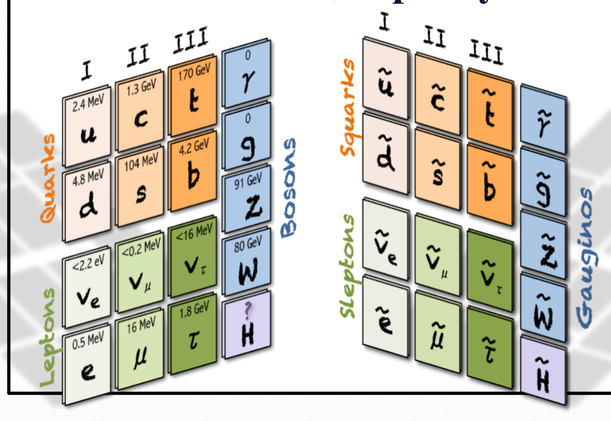
For the ATLAS Collaboration

The ATLAS trigger system



SuperSymmetry (SUSY)



SUSY is the most popular extension of the Standard Model (SM). It answers many of the SM open questions at once:

- Higgs mass hierarchy problem,
- dark matter candidate,
- unification of forces.

The challenge of triggering on SUSY

- SUSY is very predictive in terms of spins and couplings, but it tells us nothing about the masses (after symmetry breaking).
- Result: a huge number of theoretical models. E.g. consider all possible mass hierarchies between all SUSY particles ⇛ 9! models.
- SUSY searches have a very large phase-space to scan. The trigger needs to be inclusive enough to provide a good coverage of predicted physics,

⇛ and make sure our data will contain the unexpected!

The main ATLAS triggers in 2012

Signature	Offline selection	Trigger Selection L1	Trigger Selection EF	L1 Peak Rate (kHz) L_{peak}=7e33/cm^{2}s	EF Avg. Rate (Hz) $L_{avg.}$=5e33/cm^{2}s
Single leptons	Isolated μ, p_T >25 GeV	15 GeV	24 GeV	8	45
	Isolated e, p_T >25 GeV	18 GeV	25 GeV	17	70
Two leptons	Two μ's, each p_T >15 GeV	2×10 GeV	2×13 GeV	1	5
	Two μ's, p_T >20, 10 GeV	15 GeV	18, 8 GeV	8	8
	Two e's, each p_T >15 GeV	2×10 GeV	2×12 GeV	6	8
	Two e's, p_T >25, 10 GeV	18 GeV	25, 7 GeV	17	5
	Two τ's, p_T >45, 30 GeV	15, 11 GeV	29, 20 GeV	12	12
Two photons	Two γ's, each p_T >25 GeV	2×10 GeV	2×20 GeV	6	10
	Two γ's, p_T >40, 30 GeV	16, 12 GeV	35, 25 GeV	6	7
Single jet	Jet ($R=0.4$), p_T >370 GeV	75 GeV	360 GeV	2	5
	Jet ($R=1.0$), p_T >470 GeV		460 GeV		2
E_T^{miss}	E_T^{miss} >150 GeV	40 GeV	80 GeV	2	17
Multi-jets	4 jets, each p_T >85 GeV	4×15 GeV	4×80 GeV	1	8
	5 jets, each p_T >60 GeV		5×55 GeV		2
	6 jets, each p_T >50 GeV		6×45 GeV		4
b−jets	4 jets, each p_T >50 GeV out of which one is b−tagged	4×15 GeV	4×45 GeV plus b−tag	1	4
Total				< 75	400

Dedicated SUSY triggers in 2012

Selection	EF trigger election	EF Avg. Rate (Hz) $L_{avg.}$=5e33/cm^{2}s
Single jet & E_T^{miss}	Jet E_T >145 GeV & EF-only E_T^{miss} >70 GeV	8
Single jet & E_T^{miss} & $\Delta\phi$(jet,E_T^{miss})	Jet E_T >80 GeV & E_T^{miss} >70 GeV & $\Delta\phi$ >1.0 rad	8
H_T	>700 GeV	8
Single electron & E_T^{miss}	Electron p_T >25 GeV & EF-only E_T^{miss} >35 GeV	26
Single muon & single jet & E_T^{miss}	Muon p_T >24 GeV & jet E_T >65 GeV & EF-only E_T^{miss} >40 GeV	15
Single photon & E_T^{miss}	Photon p_T >40 GeV & EF-only E_T^{miss} >60 GeV	5
3 electrons	p_T > 18, 2×7 GeV	<1
3 muons	p_T > 18, 2×4 GeV	<1
3 electrons & muons	p_T > 2×7 (e), 6 (μ) GeV	<1
	p_T > 7 (e), 2×6 (μ) GeV	<1

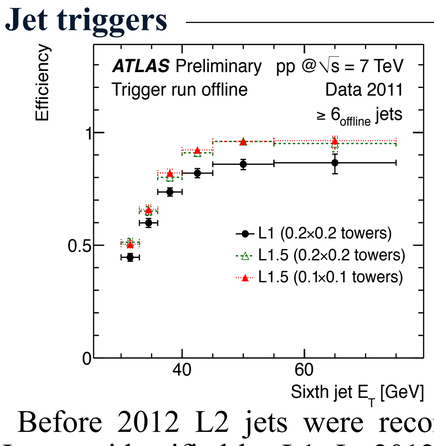
- The $\Delta\phi$ selection is applied at EF, between the E_T^{miss} and the two leading jets with p_T > 45 GeV.
- H_T is the sum of jet p_T for jets with p_T > 45 GeV, and is calculated in events that already satisfied the requirement of a leading jet p_T > 145 GeV.

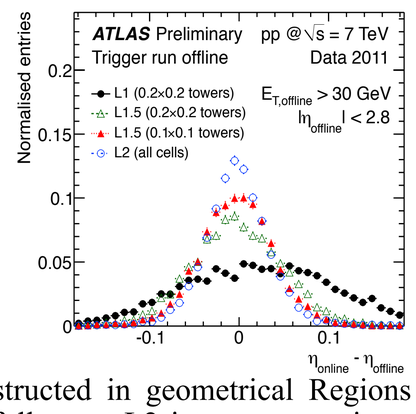
Trigger Performance improvements in 2012

2012 trigger challenges

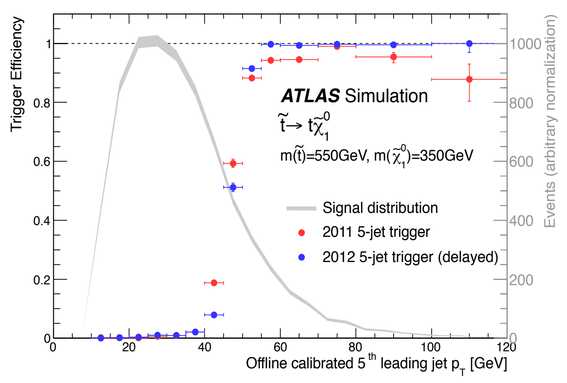
LHC operation with a higher center-of-mass energy and luminosity resulted in trigger rates an order of magnitude higher in 2012 than in 2011, as well as in large non-linearity in trigger rates as a function of luminosity due to pile-up.

Jet triggers





Before 2012 L2 jets were reconstructed in geometrical Regions of Interest identified by L1. In 2012 full-event L2 jet reconstruction was performed using energies in L1 trigger towers (so-called L1.5). This reduces inefficiency for near-by jets and improves the reconstruction of cluster parameters, such as η. EF already used full-event reconstruction.



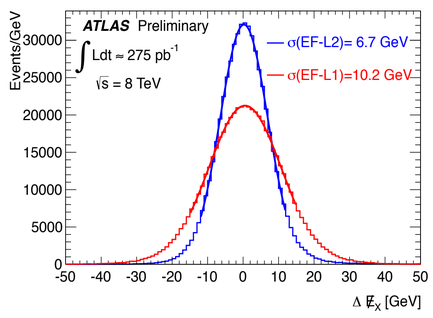
In addition, the L1 multiplicity requirement was changed from 5 to 4 jets, further reducing close-by-jet inefficiencies, as demonstrated in a $\tilde{t} \to t\tilde{\chi}_1^0$ simulated data sample.

E_T^{miss} triggers

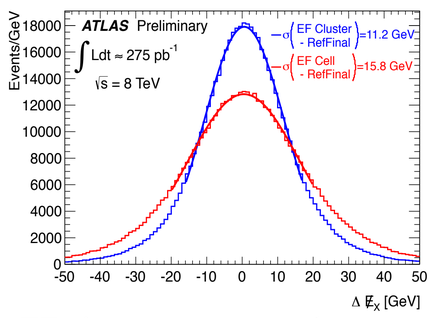
Despite the strong pile-up effects, 2012 improvements boosted the E_T^{miss} performance.

⇛ The combination of the tighter L1 calorimeter noise cuts for $|\eta|$>2.5 and the addition of a calculation of E_T^{miss} at L2 resulted in much lower L1 thresholds in 2012.

⇛ Additional option of L1 veto on the first three bunches of a train reduced the pile-up rate variations and allowed even lower thresholds.



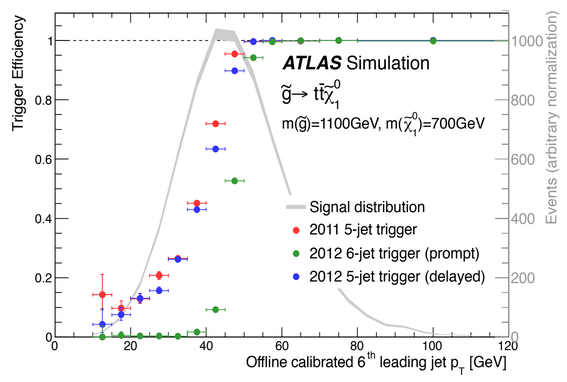
L2 improvements: E_T^{miss} calculated from calorimeter front-end-board sums, improves L1 resolution and provides rate reduction.

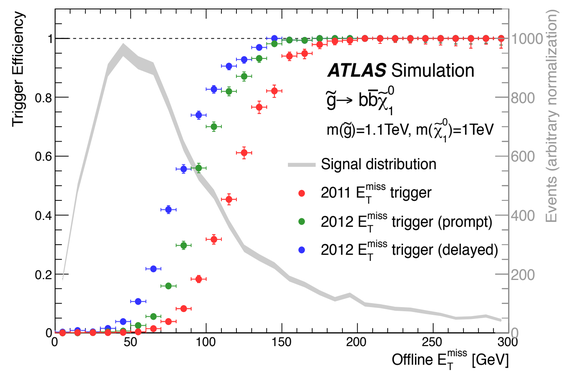


EF improvements: change to hadronic scale (similar to offline), improved resolution and robustness w.r.t. pile-up.

SUSY delayed stream

Signature	EF trigger Selection Prompt	EF trigger Selection Delayed
Multi-jets	4×80 GeV	4×65 GeV
	5×55 GeV	5×45 GeV
	6×45 GeV	
H_T	700 GeV	500 GeV
Jet ($R=1.0$)	460 GeV	360 GeV
E_T^{miss}	80 GeV	60 GeV





Looser selections for multi-jet triggers (in jet multiplicity) and E_T^{miss} are available in the delayed stream and the gain is shown for two simulated SUSY signal datasets.

The improvements made to jet and E_T^{miss} triggers for 2012 together with new trigger selections and the addition of a delayed processing stream have allowed ATLAS to meet the challenges of increased luminosity and pile-up and maintain excellent efficiency for SUSY signals in 2012 data taking.