Implementation and Performance of the ATLAS Jet Trigger

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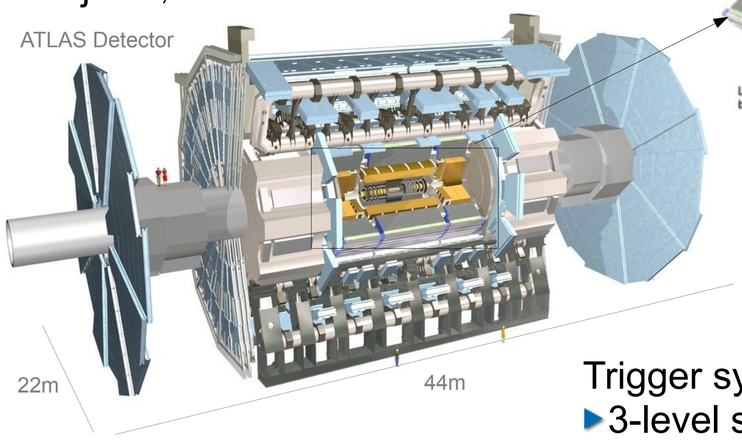
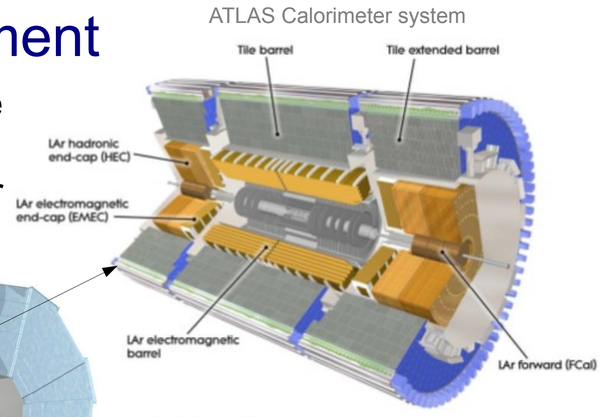
1. The ATLAS Experiment

ATLAS is designed for a large variety of physics at the LHC,
- jets are most common detector objects,

ATLAS Detector



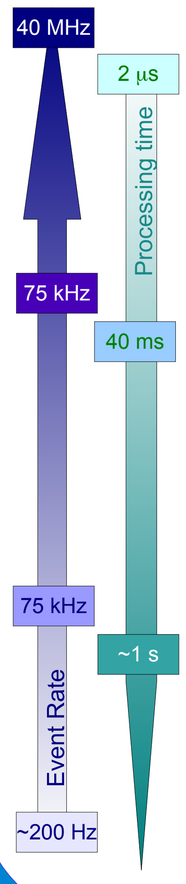
ATLAS Calorimeter system



LHC Design parameters
- Luminosity: 10^{34} cm^{-2}s^{-1}
- Bunch crossings: 40 MHz
- CM energy: 14 TeV

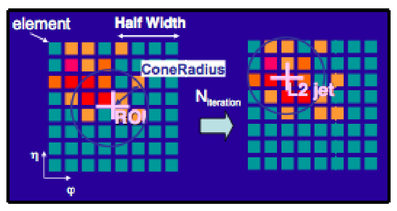
Trigger system used to limit rate,
- 3-level system implemented in hardware and software

2. ATLAS Jet Trigger



Level 1: *fast decision with limited resolution*
- implemented with custom designed hardware,
- sliding window (0.8x0.8 in η, ϕ),
- scans for local transverse energy maxima, which provide starting points (seeds) for Level 2 algorithms.

Level 2: *access to full detector granularity and resolution*
- considers only *Region of Interest*s (RoI) seeded by Level 1 triggers,
- iterative cone algorithm calculates the energy weighted position,
- fully calibrated detector objects,
  - two weights, applied to electro-magnetic and hadronic energy deposits.



Event Filter (EF): *sophisticated offline-like algorithms*
- algorithms reconstruct only RoIs passed by Level 2,
- potentially full event access,
- offline calibration available.

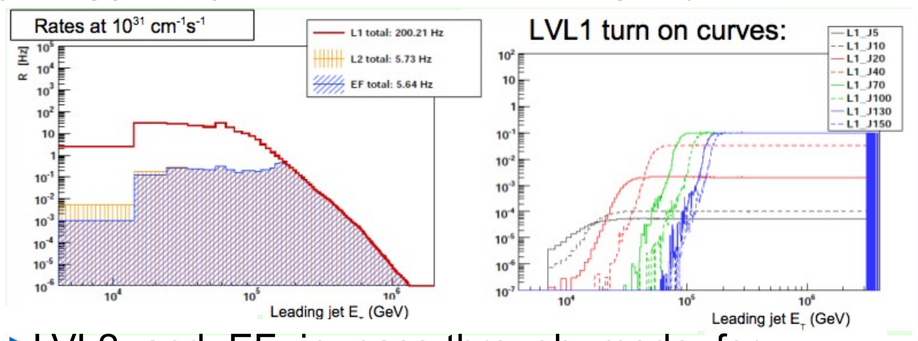
3. Jet Trigger menu

- provide a set of jet trigger objects to select interesting physics events.

Single Jet Triggers

Initial luminosity: 10^{31}cm^{-2}s^{-1}

LVL1 threshold (GeV)	Prescale
5	200k
10	100k
20	5k
40	300
70	50
100	10
130	1
150	1



- LVL2 and EF in pass-through mode for initial luminosity,
- Total single jet rate ~6Hz.

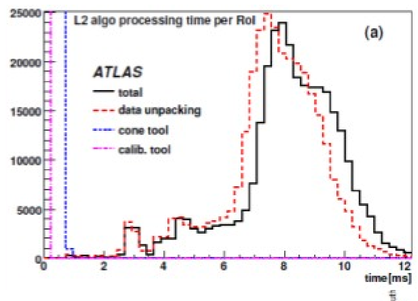
Luminosity: 10^{32}cm^{-2}s^{-1}

LVL1 thr. (GeV)	Prescale	LVL2 thr. (GeV)	Prescale
5	30k	5	10
10	12k	10	10
20	1k	20	10
40	50	40	20
70	1	70	160
100	1	100	40
130	1	130	1
150	1	150	1

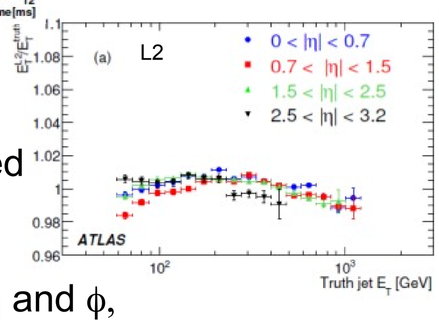
More examples of Jet Triggers:
- forward jets:
  - fj70 (QCD physics),
  - 2 fj25, $\Delta\eta$>3 (VBF Higgs, QCD),
- jet + missing ET,
  - j70+ETmiss 30 (SUSY, Higgs),
- jets + sum of all jets ET,
  - 6j40 + JE240: (top physics).

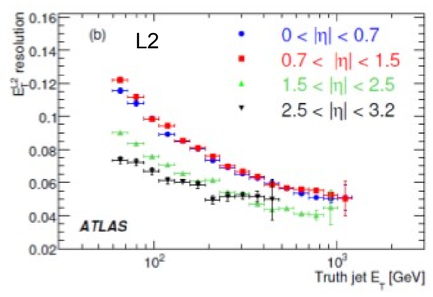
4. Performance

Level 2:
- data unpacking dominates the processing time



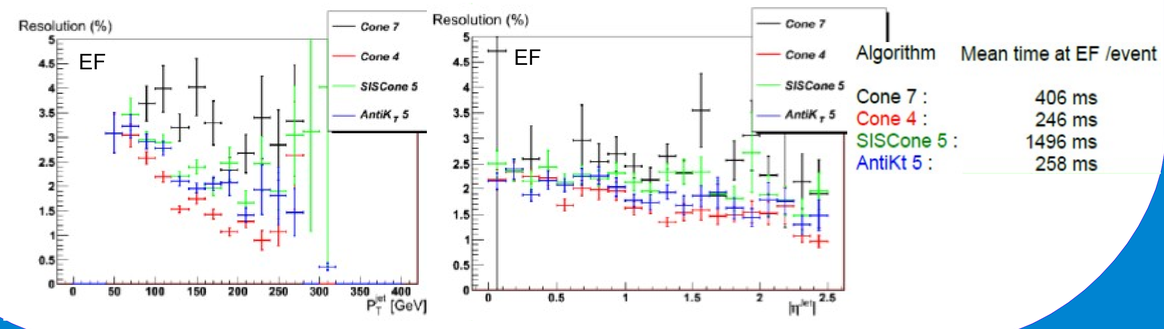
Alternative to CELL based Jets:
- receive energy sums from the ROD corresponding to each Front-End board (FEB)
  - reduces data unpacking and iteration times,
  - algorithm time improved by factor of 3,
- similar performances,
  - position resolution: 0.03 in η, 0.01 in ϕ,
  - linearity within 2%.





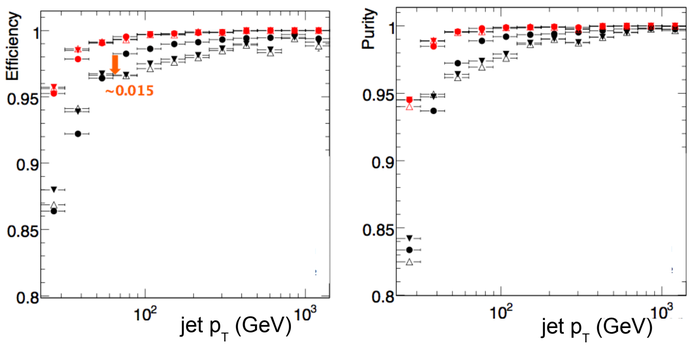
EF:

Jet resolution measured with respect to offline jets:
- RoI size: 1.6x1.6 in η and ϕ,
- tested various algorithms and cone radii,
- small radius parameter gives better resolutions due to window size,



5. Physics implications of Jet Algorithms

- cone algorithms have more split/merged jets:
  - AntiKT has higher reconstruction efficiency and purity:
    - <1% for p_T>60 GeV,
    - 5% for p_T<30 GeV,



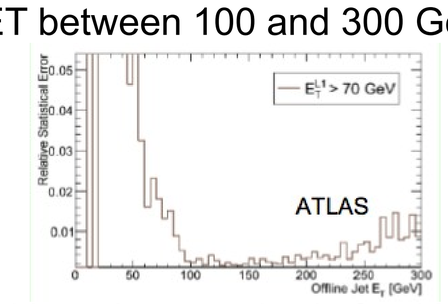
6. Data driven performance studies

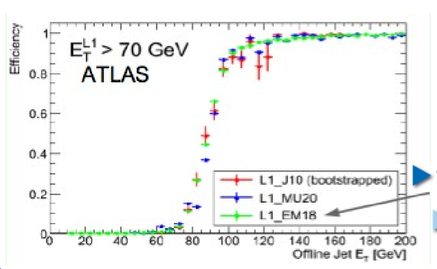
Developing methods to determine trigger efficiencies directly from real data

- Bootstrap method:
  - relative efficiency from single jet triggers,

$$\mathrm{eff(L1\_J70)} = \mathrm{eff(L1\_J10)} \times \frac{\mathrm{eff(L1\_J70)}}{\mathrm{eff(L1\_J10)}}$$

- Single muon tagged events:
  - statistical error with respect to jet E_T for 10pb^{-1} below 1% for ET between 100 and 300 GeV





- turn on curves with various methods for 10pb^{-1}:
  - worse resolution for bootstrap method due to higher E_T trigger prescales.

7. Summary and conclusions

- The ATLAS Jet trigger has been designed to cover a large variety of physics topics, from QCD to searches beyond the standard model (charged Higgs, SUSY, extra dimensions, ...).

- To cope with the high LHC rate, the trigger is designed in three levels:
  - first level is hardware based, running with coarse granularity,
  - second level runs dedicated, simplified cone algorithm,
    - good linearity in jet energy scale after calibration (2%),
  - third level (Event Filter) runs offline-like algorithms,
    - many algorithms available, best performance with AntiKT,

- Data driven performance studies are being developed and tested using MC simulation.