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

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

2. ATLAS Jet Trigger

Level 1: fast decision with limited resolution
- implemented with custom designed hardware,
- sliding window (0.8x0.8 in \eta, \phi),
- 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 Interests (RoI) seeded by Level 1 triggers,
- iterative cone algorithm calculates the energy weighted position,
- fully calibrated detector objects,
- two weights, applied to electromagnetic 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

<table>
<thead>
<tr>
<th>Initial luminosity: 10^{34} cm^-2 s^-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVL1 turn-on curves:</td>
</tr>
</tbody>
</table>
| \begin{tabular}{|c|c|}
| LVL1 & Prescale \\
|---|---|
| 5 & 20x \\
| 10 & 100x \\
| 20 & 5x \\
| 40 & 300 \\
| 70 & 50 \\
| 100 & 10 \\
<table>
<thead>
<tr>
<th>150 &amp; 1</th>
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<tbody>
<tr>
<td>LVL2 turn-on curves:</td>
</tr>
</tbody>
</table>
| \begin{tabular}{|c|c|}
| LVL2 & Prescale \\
|---|---|
| 5 & 30x \\
| 10 & 12x \\
| 20 & 10x \\
| 40 & 9x \\
| 60 & 7x \\
| 80 & 6x \\
| 100 & 4x \\
| 120 & 3x \\
<table>
<thead>
<tr>
<th>150 &amp; 1</th>
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<tbody>
<tr>
<td>More examples of Jet Triggers:</td>
</tr>
</tbody>
</table>
| \begin{itemize}
<p>| forward jets, |
| j70 (QCD physics), |
| 2 fj25, \Delta \eta \geq 3 (VBF Higgs, QCD), |
| jet + missing ET, |
| j70 + ETmiss 30 (SUSY, Higgs), |
| jets + sum of all jets ET, |</p>
<table>
<thead>
<tr>
<th>6j40 + JE240: (top physics).</th>
</tr>
</thead>
</table>

Luminosity: 10^{34} cm^-2 s^-1

4. Performance

- 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 \eta, 0.01 in \phi, linearity within 2%.

EF:
- Jet resolution measured with respect to offline jets:
  - RoI size: 1.6x1.6 in \eta and \phi,
  - 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:
    - \% for p_T overs 60 GeV,
    - 5\% for p_T \leq 30 GeV,
  - Cone: no trigger applied
  - Cone: event minus L1
  - AntiKT: no trigger applied
  - AntiKT: event minus L1
  - Cone: event minus L1

6. Data driven performance studies

- Developing methods to determine trigger efficiencies directly from real data
  - Bootstrap method:
    - relative efficiency from single jet triggers,
      \text{e}_\text{L1,J70} = \text{e}_\text{L1,J10}\times \text{e}_\text{L1,J70}/\text{e}_\text{L1,J10}
  - 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,
  - 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.