Performance of the FastTracKer in Missing Transverse Energy trigger in ATLAS

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At designed LHC $\sqrt{s} = 14$ TeV & $\mathcal{L} \sim 10^{34}$ cm$^{-2}$s$^{-1}$, each second:

- $\sim 10^9$ p-p interactions
- $\sim 10^3$ W events
- $\sim 10$ top events

Only few hundred events can be recorded

<table>
<thead>
<tr>
<th>Run 1 (2009-2013)</th>
<th>Run 2 (from 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mathcal{L} \sim 7 \times 10^{33}$ cm$^{-2}$s$^{-1}$</td>
<td>$\mathcal{L} \sim 1 \times 10^{34}$ cm$^{-2}$s$^{-1}$</td>
</tr>
<tr>
<td>$\langle \mu \rangle \gtrsim 25$</td>
<td>$\langle \mu \rangle \gtrsim 60$</td>
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<tr>
<td>bunch spacing 50 ns</td>
<td>25 ns</td>
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<tr>
<td>$\sqrt{s} = 8$ TeV</td>
<td>13-14 TeV</td>
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- increase in low $p_T$ interaction cross section

New redefinition of trigger needed for Run 2
Tracking in ATLAS Trigger system for Run II

Full tracking information immediately after the first trigger level in Run 2

- selection of events with $b$’s and/or $\tau$’s
- tracking: most powerful separation of signal with $b$ and $\tau$ from QCD
- $H \rightarrow b\bar{b}$, $H \rightarrow \tau\bar{\tau}$, New Physics
- lepton isolation using tracking

FastTracKer (FTK): global and fast tracking
FastTracKer (FTK)

- **custom electronics system**: global track reconstruction ($\sim 100 \mu s$)
- highly **parallel** system organized in 64 $\eta - \phi$ towers
- track reconstruction: $p_T > 1$ GeV, $|\eta| < 2.5$

**Performance in $t\bar{t}$ sample**

**Not matched to truth in $H \rightarrow \tau\tau$**

CERN-LHCC-2013-007 ATLAS-TDR-021
FTK tracks in trigger objects and chains

FTK tracks can help in many ways:

- **Primary Vertices** (PV): from FTK tracks, (pileup rejection)
- **jets:**
  - \(b\)-tagging with FTK tracks
- **muons and electrons:** track-based isolation
- \(\tau\): number of FTK tracks in isolation cones (FTK Level-2 \(\tau\) trigger), \(H \rightarrow \tau\tau\) increase of acceptance of 28% for \(\tau_{\text{had}}\tau_{\text{had}}\)
- **Missing Transverse Energy** (MET): improve trigger resolution using track and PV information
Missing Transverse Energy (MET)

Missing Transverse Energy:
- *energy imbalance* measure in the transverse plane due to:
  - particles escaping the detector
  - detector effects (noise)
  - unaccounted physics processes (pile-up)

The challenge of MET triggers:
- **global quantity**: full detector (no RoI)
- high rate of low $p_T$ background events
- very important for New Physics!
MET = **hard term** (high $p_T$ jets) + **soft term** (low $p_T$ objects)

**Run 1** MET triggers: only calorimetric information for soft and hard term $\rightarrow$ very sensitive to pileup

**Run 2** global tracking is fundamental. Exploiting **FTK tracks from PV for soft term:**

1. better resolution
2. reject pileup contribution

More sophisticated combination of calorimetric information with FTK tracks:

**Particle Flow!**

particle flow jets with better resolution for hard term
Particle flow (PFlow) algorithm main idea

1. match tracks (charged particles) to calorimeter energy deposits (clusters)
2. tracks + remaining clusters are used

**Benefits**

1. **better energy, \( \eta \) and \( \phi \) resolution** than calorimeter one of low momentum particles
2. only tracks coming from Primary Vertex (PV) taken into account
   \( \Rightarrow \) **pileup contribution reduction**

ATLAS on-going studies of application of PFlow to **jets** and **Missing Transverse Energy** with offline tracks

\( \Downarrow \) improvements in resolution and scale
Jet response comparison central region

- **PFlow jets with FTK tracks**
- **Standard jets**: with calibrated clusters
- **PFlow jets with offline tracks**
- **better resolution for low pt PFlow jets**
MET resolution

$ZH \rightarrow \nu\nu bb$

**ATLAS**

$\sqrt{s} = 14$ TeV

Work in progress

Simulation

offline PFlow $E_T^{\text{miss}}$ better resolved than

FTK PFlow $E_T^{\text{miss}}$ better than FTK+JET
Performances studied for a trigger chain:

Level 1 MET > 50 GeV \rightarrow \text{HLT MET} > 80 \text{ GeV}

\text{turnon curve} = \frac{\text{\# events after L1 \& HLT}}{\text{\# events after L1}} \text{(offline MET)}

- cut on HLT MET: \textbf{the same bkg rate (multi-jet) wrt Run1 HLT MET (only calorimter)} > 80 \text{ GeV}
FastTracKer (FTK) will provide tracks at trigger level (after L1)

many trigger chains will take advantage from global FTK track information

FTK tracks in MET trigger chain and particle flow jets:
  - improvement in pflow jet resolution wrt to standard offline jets
  - steeper turn on curve of PFlow MET wrt Standard jet MET turn on curve
FastTracKer (FTK)

- FTK: custom electronics system for global track reconstruction ($\sim 100 \mu s$) after L1
- highly parallel system organized in 64 $\eta - \phi$ towers

- full-resolution hits from Pixel and Silicon strip

- **Associative Memory & Track Fitter**: pattern recognition and first track fitting

- **Second Stage Fit Board**: refines the track quality

- tracks with $p_T > 1$ GeV, $|\eta| < 2.5$ at the beginning of L2
At the HLT:

- **Topological Clusters**
- **Tracks from FTK**
  - $p_T > 1 \text{ GeV}$ & $p_T < 40 \text{ GeV}$
  - $|z_0|_{BL} < 110 \text{ mm}$ & $|d_0|_{BL} < 2 \text{ mm}$
  - implicit good track: at least 9 hits

**Samples** (all @ $\langle \mu \rangle = 60$):
- Signal: $ZH \rightarrow \nu \nu bb$
- multi-jet: $20 < p_T^{\text{truth lead}} < 200 \text{ GeV}$
miss
x - E_{miss, HLT}
xE
miss
multi-jet, $\mu=60$

$\sqrt{s} = 14$ TeV