ATLAS Hardware Track Trigger performance studies for HL-LHC

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HIGH LUMINOSITY LHC

Need flexibility to accommodate rates/occupancy higher than expected ➡ **Two level hardware trigger**

Increased acceptance of hadronic signatures can be handled by impact parameter requirements at L1

LEVEL-1 TRACKING (L1 TRACK)

- Around L0 RoIs with reduced number of tracker layers
  ➥ Low resolution tracks with $p_T > 4$ GeV
- Reduces front-end electronics readout rate by x 10
- Pixels readout developments since the TDR [1] will limit the number of modules accessible to L1Track w.r.t. to the assumptions. Final configuration is being defined

➡ What can be gained in acceptance/rejection from reading out the outer most pixel layers?

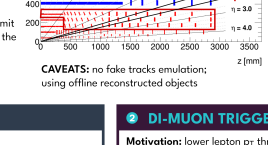
L1 TRACK EMULATION USING OFFLINE-REFIT TRACKS

Use high precision offline tracking algorithm to fit hits in 8 tracker (ITk) layers

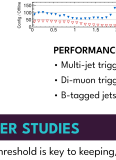
3 scenarios considered:

- ➡ **Offline tracking** (all layers)
- ➡ **TDR** (outer pixel layers + strip layers)
- ➡ **Strip-only** (worst case scenario: no pixel readout at L0 rate)

- Smear offline tracks impact parameters (d_0/z_0)
- Add additional factor 2 to account for differences between online and offline track reconstruction
- Apply 95% track reconstruction efficiency
- Investigate algorithms that can be implemented in hardware with current/future technologies



CAVEATS: no fake tracks emulation; using offline reconstructed objects



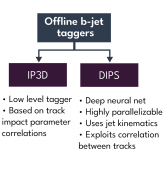
PERFORMANCE STUDIES [2]

- Multi-jet triggers 1
- Di-muon triggers 2
- B-tagged jets 3

1 MULTI-JET TRIGGERS STUDIES

Motivation: key benchmark channels such as HH→4b

Trigger: ≥ 3 jets, p_T > 65 GeV, |η| < 3 + common vertex requirements
➥ needs tracking



Signal: HH→4b
Background: dijets

- Associate jets to tracks in cone

Scan over output of a BDT that combines variables based on z_0/d_0 separation and track multiplicity

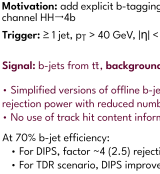
At 85% HH→4b signal efficiency:

- Factor ~10 (9) rejection for TDR (Strip-only) scenarios

2 DI-MUON TRIGGER STUDIES

Motivation: lower lepton p_T threshold is key to keeping/increasing acceptance in channels such as H→ ττ and SUSY models

Trigger: ≥ 2 muons, p_T > 10 GeV, |η| < 2.5 + common vertex requirement
➥ needs tracking



Signal: Z→μμ
Background: dijets

- Associate muons to leading track in cone

Scan over distance along z of the two tracks (Δz_0)

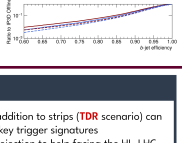
At 96% Z→μμ signal efficiency:

- Factor ~4.5 (1) rejection for TDR (Strip-only) scenarios

3 B-TAGGED JETS STUDIES

- Low level tagger
- Based on track impact parameter correlations

- Deep neural net
- Highly parallelizable
- Uses jet kinematics
- Exploits correlation between tracks



Motivation: add explicit b-tagging on multi-jet triggers for benchmark channel HH→4b

Trigger: ≥ 1 jet, p_T > 40 GeV, |η| < 2.5 + b-tagging
➥ needs tracking

Signal: b-jets from tt̄, **background:** light-flavor jets from tt̄

- Simplified versions of offline b-jet taggers are used to demonstrate rejection power with reduced number of layers for track fitting
- No use of track hit content information as it is not simulated for L1Track

At 70% b-jet efficiency:

- For DIPS, factor ~4 (2.5) rejection for TDR (Strip-only) scenarios
- For TDR scenario, DIPS improves rejection by factor ~1.6 w.r.t. IP3D

CONCLUSIONS

- Using the outer-most pixel layers in addition to strips (**TDR** scenario) can improve background rejection in some key trigger signatures
- **Strip-only** scenario can add sizable rejection to help facing the HL-LHC era

REFERENCES AND ACKNOWLEDGMENTS

[1] Technical Design Report for the Phase-II Upgrade of the ATLAS TDAQ System, ATLAS Collaboration, Sep 2017, CERN-LHCC-2017-020, ATLAS-TDR-029
[2] Approved plots for the L1Track Trigger project, ATLAS Collaboration, twiki: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/L1TrackPublicResults

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