Physics motivation

- **b**-quarks play an important role in many particle physics analyses
  - 3rd generation particle
  - Decay product of top quarks and Higgs boson
- Fully hadronic final states
  - \( HH \rightarrow b\bar{b}bb, bH \rightarrow b\bar{b}b \)
  - \( t\bar{t}H \rightarrow bq\bar{q}' b\bar{q}' \bar{b} \)
  - \( g\bar{g} \rightarrow b\bar{b}bb + \text{MET} \)
  - ...

Challenges to overcome

- Huge jet background (from lighter quarks and gluons)
- Efficient selection \( \rightarrow \) Low jet \( p_T \) threshold
- Real-time selection \( \rightarrow \) CPU efficient

ATLAS trigger system

The ATLAS trigger has two levels:

**Level1**

- Hardware-based
- Utilises calorimeter and muon detector informations
- Regions of Interest (RoIs) are identified around calorimeter jets

**High Level Trigger (HLT)**

- Software-based
- Utilises information from whole detector or RoIs
- Reconstruction algorithms close to offline algorithms

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[1]
**ATLAS b-jet trigger**

**Goal:** Identify and separate jets stemming from light quarks or gluons (light-jets), and heavy quarks (c- or b-jets)

**Identification:** Relies on exploiting b-hadron properties
- Long lifetime
- Secondary vertex
- Large impact parameters
- Large mass of displaced vertex
- Possible semi-leptonic decays

**General overview of b-jet trigger workflow**

**HLT jets:**
- Anti-kt ($R = 0.4$) jet clustering algorithm inside RoIs
- Pile-up subtraction + $E_t$ and $\eta$ calibration

**Primary-vertex (PV) finding:**
- Super-RoIs are defined as a combination of all jet RoIs
- Narrow in $\eta - \phi$, full z-range

**Fast tracking only performed within super-RoI (CPU saving)**
- PV defined as combinations of tracks compatible in z-position with largest $\sum p_T^2$ (as in offline)

**Precision tracking:**
- Fast tracking inside RoIs + track candidate overlap resolution
- Uniform performance vs. $p_T$
- Apply offline calibration to HLT jets

**Flavour tagging:**
- Multivariate analysis techniques to combine many weakly separating quantities into one strong flavour tagger
- Aim: Similar algorithm to offline (true for beginning of Run-2)
- Reach highest combined tagging efficiency (online $\times$ offline)
- Tagger trained on mixture of $t\bar{t}$ and $Z'$ samples
- $Z'$ to reduce overtraining at high $p_T$ (above ~ 250 GeV)
- Lowest unprescaled single b-jet triggers are at 225 GeV
- Performances has improved over the years
- Stable performance with increasing pile-up

**Precision Tracking**

**Flavour Tagging**
Triggers in heavy ion collisions

- Study energy loss mechanism of partons inside quark-gluon-plasma
- Predicted to be smaller for heavy quarks ('dead cone' effect)
- High rates and CPU cost from tracking do not permit using same triggers as in pp runs
- Require geometric match of muon and jet (Muon-jet triggers)
- Additional light-jet suppression allows to lower $E_T$ threshold

Tagger calibration

- Scale factors (SFs) to correct for data-MC differences
  - $\text{SF}_b = \frac{\epsilon_{b,\text{data}}}{\epsilon_{b,\text{MC}}}$; $\epsilon_b = b$-tagging efficiency
- Derived in tbar dilepton ($\mu\mu bb$) enriched data
- Per-jet SFs available

- Overall efficiency for physics analysis: $\epsilon_{b,\text{Trig|Off}} \times \epsilon_{b,\text{Off}}$

References

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