High Level Trigger Filters for Jets and Missing $\mathrm{E_T}$

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Outline

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- HLT Framework
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- Configuration Example
- HLT JetMet Trigger Menu

- Introduction to the HLT Framework
- Overview of the Available Filters at HLT
- Sample CMSSW HLT Configuration File
- Review of the Jet and $\not{E}_T$ Trigger Menu from PTDR Volume II

High Level Trigger Framework

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- Each HLT trigger path is a sequence of modules, e.g.

```
path HLT1MET = {l1extra & l1s1MET &
                pre1MET & met, hlt1MET91}
```

- Processing of the trigger path stops once a module returns false.
- Two HLT Objects
  - `TriggerResults` reports the status (`NotRun, Pass, Fail, Exception`) of the HLT trigger paths, as well as the HLT module and pathname information.
  - `HLTFilterObjectWithRefs` provides references back to the objects (jets, for example) which satisfied the HLT filter requirements.

For more details visit the HLT twiki page:
https://uimon.cern.ch/twiki/bin/view/CMS/HighLevelTrigger

HLT Filters

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- Available HLT filters currently reside in the `HLTrigger/HLTexample` directory.
- Generic templated filter algorithms in CMSSW_0_9_0 are:
  - `HLTSinglet.cc`
  - `HLTDoublet.cc`

    For CMSSW_1_0_0:
    - `HLTSmartSinglet.cc`
    - `HLTGlobalSums.cc`
- Specific instances of `HLTSinglet.cc`:
  - `HLT1CaloJet`
  - `HLT1CaloMET`
  - `HLT1Muon`
  - `HLT1Photon`
  - `HLT1Electron`
- `HLTDoublet.cc` is used to make kinematic cuts between two HLTSinglet objects; e.g., acoplanarity between `HLT1CaloJet` and `HLT1CaloMET` objects.

Filter Parameters

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- `HLTSinglet.cc`:
  - Require $N \geq N^{cut}$ objects with $\mathrm{p_T}{}^{min}$ and $abs(\eta) \leq \eta^{max}$.
- `HLTDoublet.cc`:
  - Require $N \geq N^{cut}$ di-objects satisfying
    - $\Delta\phi$ (acoplanarity),
    - $\Delta\eta$, and/or
    - mass requirements.
- `HLTSmartSinglet.cc`:
  - Single cut on ANY method defined by the templated class.
- `HLTGlobalSums.cc`:
  - Require a MET observable within specified maximum and minimum values. Observables are:
    - $\sum_{CaloTower} E_T$,
    - $\not{E}_T$ significance $\equiv \not{E}_T / \sqrt{\sum E_T}$, and
    - $E_{||}$, the longitudinal component of $\sum_{CaloTower} \vec{E}$.

cmsRun Configuration Example

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```
untracked PSet options = {
    untracked bool wantSummary = true
    untracked bool makeTriggerResults =
            true
    }

module pre1MET = HLTPrescaler {
    bool makeFilterObject = true
    uint32 prescaleFactor = 1
    }
module pre1Jet = HLTPrescaler {
    bool makeFilterObject = true
    uint32 prescaleFactor = 1
    }

module l1s1met = HLTLevel1Seed {
    vstring L1Seeds = {"MET"}
    bool andOr = true
    bool byName= true
    InputTag L1ExtraTag = l1extramctruth
    }
module l1s1jet = HLTLevel1Seed {
    vstring L1Seeds = {"SingleJet60"}
    bool andOr = true
    bool byName= true
    InputTag L1ExtraTag = l1extramctruth
    }
module hltMET91 = HLT1CaloMET{
    InputTag inputTag = met
    double MinPt = 91.0
    double MaxEta= 5.0
    int32 MinN = 1
    }
module hlt1jet120 = HLT1CaloJet {
    InputTag inputTag =
            iterativeCone5CaloJets
    double MinPt = 120.0
    double MaxEta= 5.0
    int32 MinN = 1
    }

path HLT1MET = {l1s1met & pre1MET &
                hltMET91}
path HLT1JET = {l1s1jet & pre1Jet &
                hltJet120}

module out = PoolOutputModule {
    untracked string fileName = "output.root"
    #untracked PSet SelectEvents = {
    # vstring SelectEvents =
    #       { "HLT1MET", "HLT1JET"} }
    }

endpath endhlt = {out}
```

HLT JetMet Trigger Menu from PTDRv2

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Trigger	Level-1 Prescale	HLT Threshold (GeV)	HLT Rate (Hz)	CMSSW availability
SINGLE-JET	1	400	4.8 ± 0.0	✓
DOUBLE-JET	1	350	3.9 ± 0.0	✓
TRIPLE-JET	1	195	1.1 ± 0.0	✓
QUADRUPLE-JET	1	80	8.9 ± 0.2	✓
$\not{E}_T$	1	91	2.5 ± 0.2	✓
jet + $\not{E}_T$	1	180,80	3.2 ± 0.1	✓
acoplanar 2 jets	1	200,200	0.2 ± 0.0	✓
acoplanar jets + $\not{E}_T$	1	100,80	0.1 ± 0.0	✓
2 jets + $\not{E}_T$	1	155,80	1.6 ± 0.0	✓
3 jets + $\not{E}_T$	1	85,80	0.9 ± 0.0	✓
4 jets + $\not{E}_T$	1	35,80	1.7 ± 0.0	✓
$\mathrm{H_T}$ + $\not{E}_T$	1	350,80	5.6 ± 0.2	X
$\mathrm{H_T}$ + e	1	350,20	0.4 ± 0.1	X
SINGLE-JET	10	250	5.2 ± 0.0	✓
SINGLE-JET	10^3	120	1.6 ± 0.0	✓
SINGLE-JET	10^5	60	0.4 ± 0.0	✓

For $\mathcal{L} = 2 \times 10^{33}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$