

b-tag HLT
status and plans
code in 160, trigger validation

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Implementation
and performance of
b-lifetime and $b \rightarrow \mu$
for HLT-exercise and in 1.6.0

b-Lifetime Tagged HLT: Level-1

- Trigger thresholds for $L = 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
- Level 1:
 - Et (1st jet) > 150 GeV
 - Et (2nd jet) > 100 GeV
 - Et (3rd jet) > 50 GeV
 - Et (4th jet) > 30 GeV
 - or HTT > 300 GeV
- L1 is 96% efficient for hadronic t-tbar.
 - N.B. Using only Et (4th jet) or HTT is almost as good
- 0.014% efficient for minibias (= 1.1 kHz)

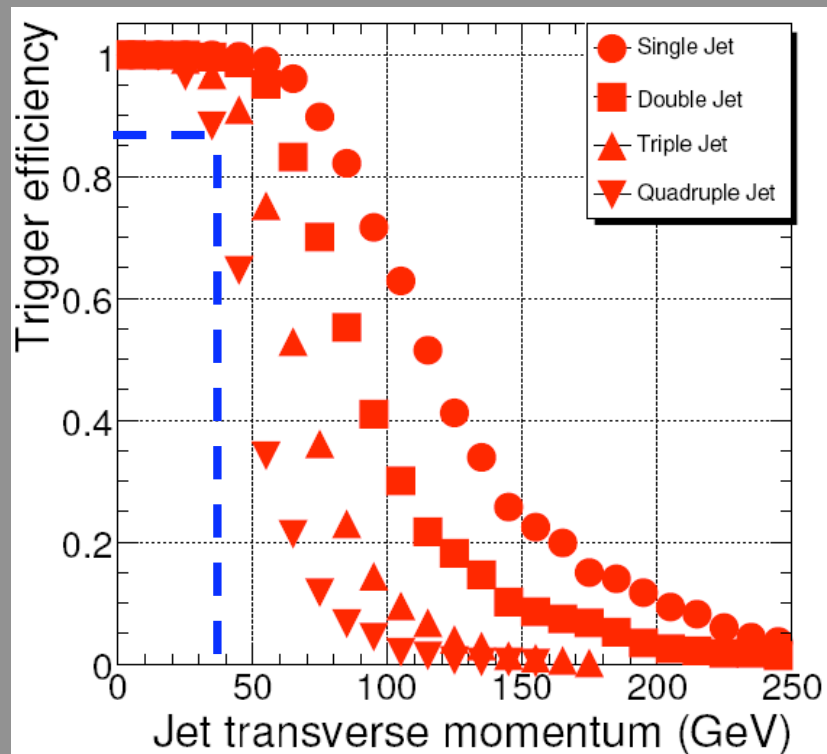
b-Lifetime HLT: Level 2

$E_t(\text{1st jet}) > 180 \text{ GeV}; E_t(\text{2nd jet}) > 120 \text{ GeV}$

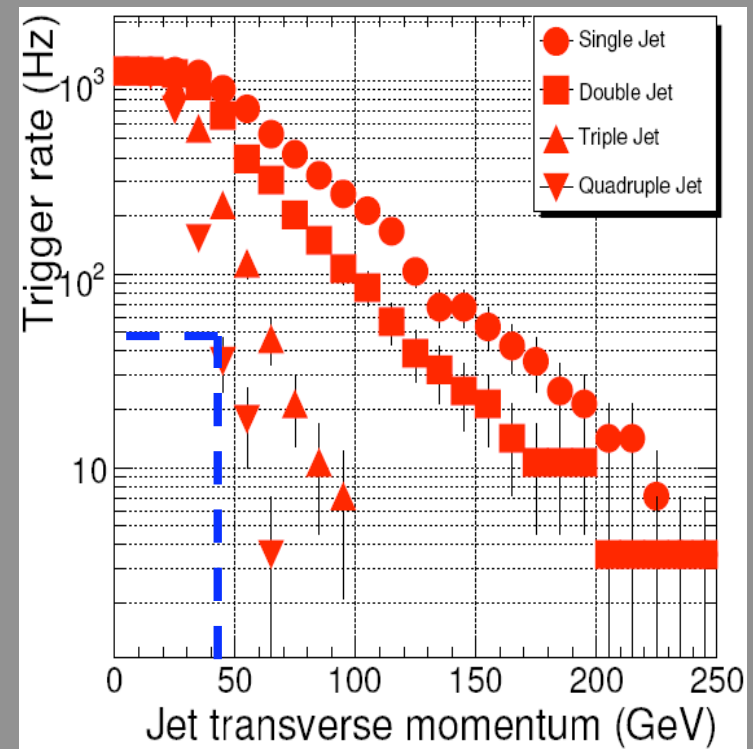
$E_t(\text{3rd jet}) > 70 \text{ GeV}; E_t(\text{4th jet}) > 40 \text{ GeV}$

or $\text{HTT} > 470 \text{ GeV}$

t-t efficiency
relative to Level 1



Minibias rate

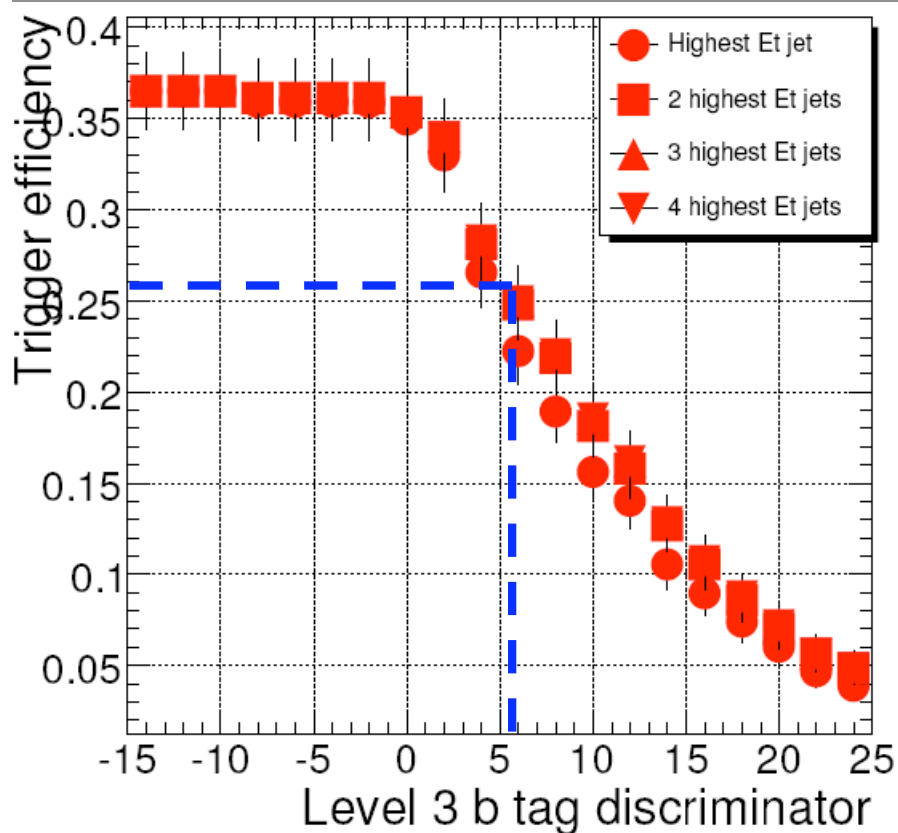


b-Lifetime HLT: Level 2.5 and 3

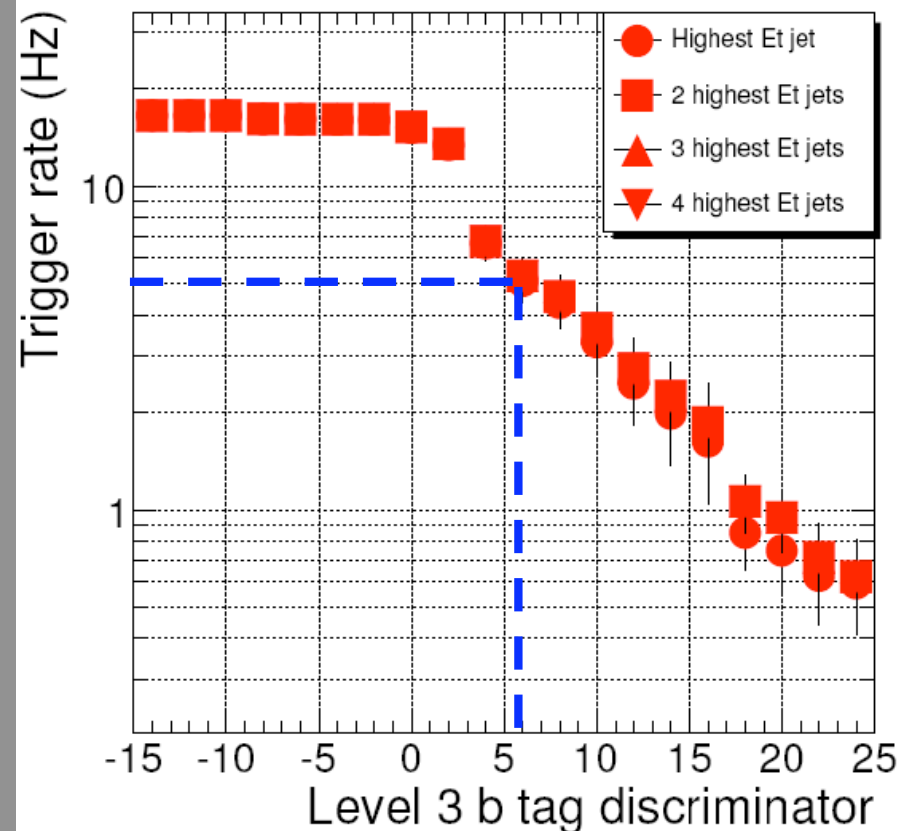
- Level 2
 - Make P.V. from pixel `triplet' tracks.
 - Select 4 highest Et jets with $E_t > 35 \text{ GeV}$.
 - Run `track-counting' b-tag on selected jets, using pixel `triplet' tracks
 - Require ≥ 1 tagged jet (≥ 2 tracks with 3-D $d_0 > 3.5s$).
- Level 3
 - Reuse P.V. from pixel `triplet' tracks.
 - Consider only jets tagged as b-jets at Level 2.5
 - Reconstruct tracks in (h,f) window around jet.
 - Stop track reconstruction when 8 hits assigned to track.
 - Run `track-counting' b-tag on selected jets, using these tracks.
 - Require ≥ 1 tagged jet (≥ 2 tracks with 3-D $d_0 > 6s$).

b-Lifetime Tagged HLT Level 3

$t\text{-}t$ efficiency
relative to Level 1



Minibias rate



$b \rightarrow \mu$ HLT: Level 1 Triggers

- Rates and Efficiencies:
 - Muon+jet Trigger
 - A_MU5_Jet15:
 - At least one muon $p_T > 5$ GeV and one jet $E_T > 15$ GeV
 - Rates at $10^{32} \text{ cm}^{-2} \text{ s}^{-1}$: 1.6 kHz
 - Efficiencies for ttbar (all hadronic/mu events): 0.74
 - Jets Only:
 - HTT250:
 - Sum of jet $p_T > 250$ GeV
 - Rates at $10^{32} \text{ cm}^{-2} \text{ s}^{-1}$: 2.56 kHz
 - Efficiencies for ttbar (all hadronic/mu events): 0.95

$b \rightarrow \mu$ HLT options

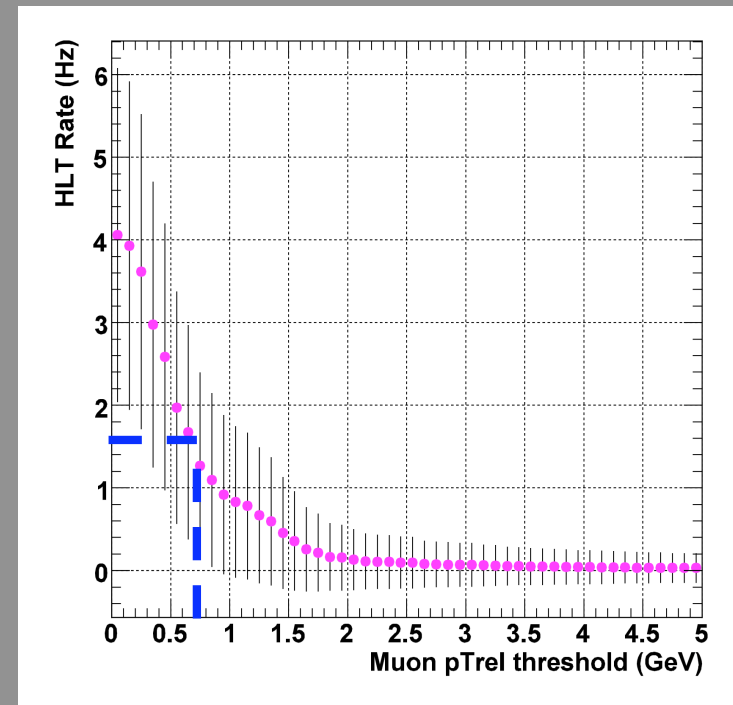
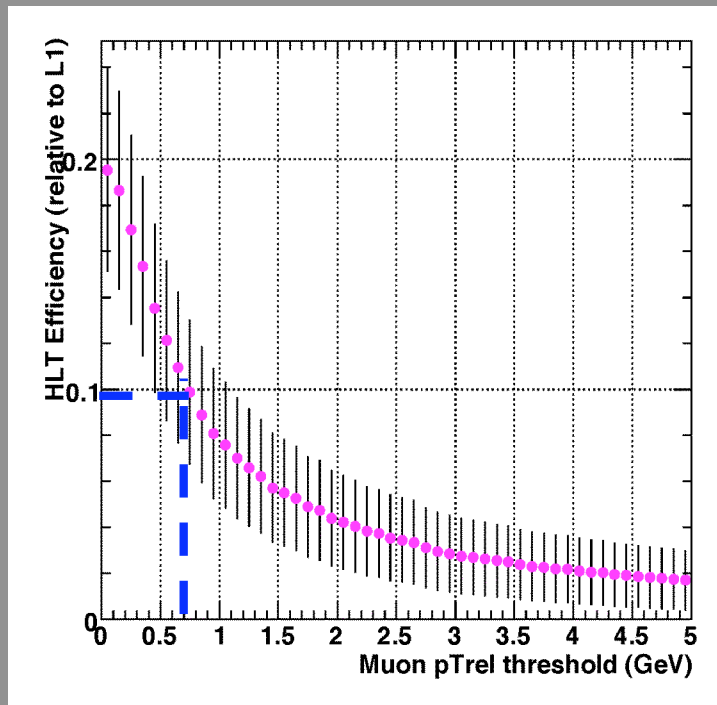
- Level 2:
 - Various num of jets and ET thresholds available
 - Those relevant for $t\bar{t}$ (all-hadronic/ μ):
 - Three jet with $p_T > 70$ GeV/c.
 - Four jets with $p_T > 40$ GeV/c.
 - Event hadronic activity $HT > 370$ GeV.
- Level 2.5:
 - Level 2 muons (Muon-chamber μ) required to be near one of the Level 2 jets, $\Delta R(\mu - j \text{ et}) < 0.4$
 - using the Soft Lepton b-tagging package.
- Level 3:
 - Use L3muons (μ confirmed by Tracker)
 - $\Delta R(\mu - j \text{ et}) < 0.4$.
 - Require μ p_T (rel) > 0.7 GeV/c w.r.t. the jet axis.

$b \rightarrow \mu$ tag in HLT

- pTrel of muon wrt jet
- ttbar efficiency
with generated μ
relative to Level 1,

L1 : A_HTT250

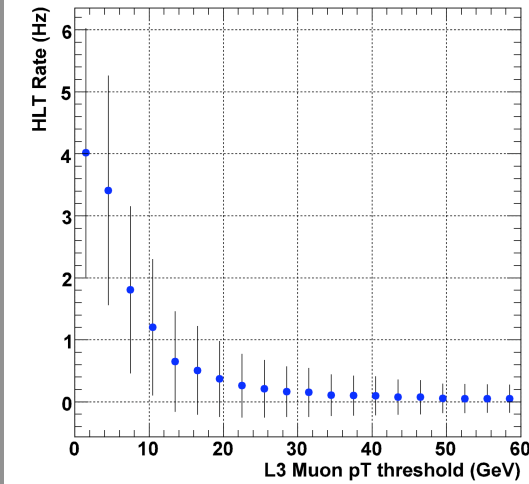
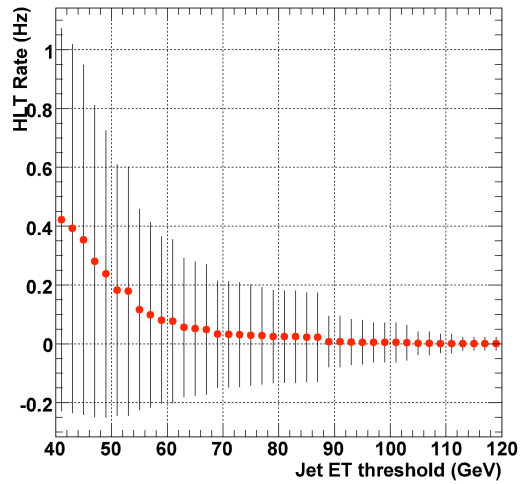
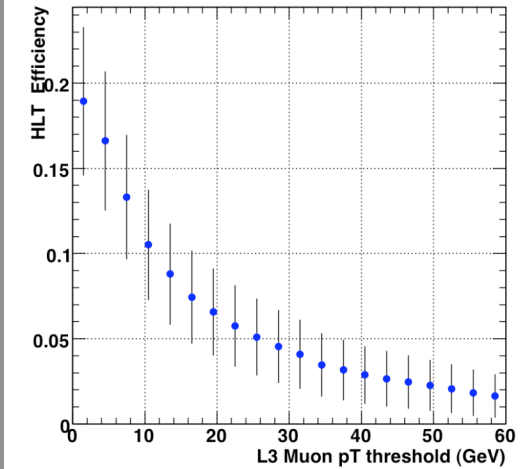
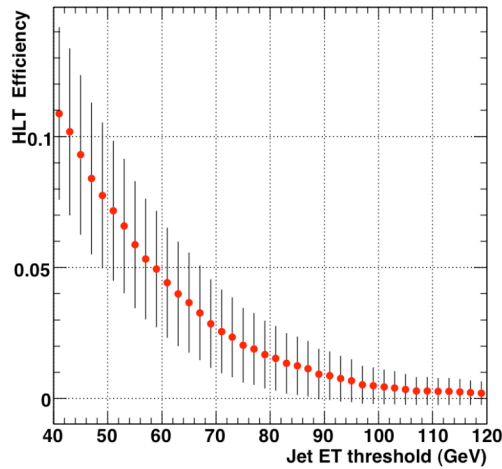
QCD Rate



$b \rightarrow \mu$ tag in HLT

- Additional knobs to control rates
- p_T of 4th jet in L2
- $t\bar{t}$

L3 muon p_T



- QCD

$b \rightarrow \mu$ HLT trigger for b-jet performance control samples

- $b \rightarrow \mu$ HLT provides jet + μ data for b tag performance measure
 - Trigger requires μ in jet with $E_t > 20$ GeV
 - prescaled by factor 20
 - has rate of 4 Hz = 40M events/year.
 - Rate dominated by low E_t jets
- For later version of optimized HLT table, define a sequence of triggers with higher jet E_t threshold, so could use smaller prescale with higher threshold in later versions of optimized HLT table.
 - used to measure b tag performance with data

b-HLT Code Infrastructure

Code Status & How to run it !

- Trigger available in CMSSW 1.3.1.HLT5
- And non-validated version in 1.6.0.pre4.
 - HLT in CMSSW 1.3.1.HLT5
 - runs on 1.2 or 1.3 data.
 - HLT in CMSSW 1.6.0
 - runs on 1.4, 1.5 or 1.6 data.
- For b-lifetime HLT:
 - Run HLTrigger/btau/BJetTrigger.cfg
- For $b \rightarrow \mu$ HLT
 - HLTrigger/btau/BSoftMuonTrigger.cfg
- For all HLT:
HLTrigger/Configuration/test/HLTTable.cfg

Software Design

- HLTrigger/btau/interface/HLTJetTag.h
 - Inherits from HLTFilter
 - Implements function "bool filter()", which says if event accepted.
 - It does so by accessing b-tagged jets from Event, & requiring that there be more than N (=1) of them etc.
- Stores in Event, an HLTFilterObjectWithRefs, which contains references to the b jets which caused the event to trigger.

Infrastructure

- Structure of b tagging algorithms (2 Stages)
 - compute the tagging variables for each algorithm (lifetime, soft lepton, ...)
 - combine (a subset of) them into a discriminator
 - more discriminators can be computed from the same set of tagging variables.
 - faster than recomputing everything
- Input objects
 - all algorithms should be able to handle all jet types inheriting from **reco::Jet**
 - interface still needs to be tweaked (using `View<Jet>`)

Status as of 1.6.0(-pre4)

- code and configuration files have been updated
 - works within the HLT Global Table
 - using pre3 + tags for IP tagger
 - Pre4+tags for $b \rightarrow \mu$ tagger
- run over 1000 QCD 380-470 GeV events, from 1.5.1 ReVal sample
 - 134 passed the **HLTB[1-4]Jet, HLTBHT** path
 - 21 passed the **HLTB[2-4]JetMu** paths
 - 2 passed the **HLTB1JetMu** (prescaled by a factor 20)
 - 24 passed the **HLTBHTMu** path
 - algorithmic part works
 - Still need to validate the results

Updates since 1.3.1-HLT6

- For IP tagger:
 - uses updated regional seeding and tracking (following the work done by Tau)
 - will be moved to a common place
- For tagger
 - can run with no primary vertex
 - When set to 'none' assumes the beam spot position and errors
 - won't compute the lepton's IP will
 - runs with no tracks
 - can tag either a CaloJet or a JTA
 - Plus other cleanups

Plans/ToDo List

- migrate IP tagger to updated 1.5.x TrackIP b-tagger
 - can compute both tracks IP and jet probability
- For both taggers:
 - improve offline package to use View<Jet> to allow all Jet types;
 - Rename all modules and sequences
- Validation
 - In the works. Have first pass code, but not committed or part of the validation suite.
 - Intend to produce threshold curves (the ones we put in the note) and tables of efficiencies.
 - We could run on L1 skimmed minibias, QCD in one p_T bin and ttbar.
 - The validation suite should run automatically on all new releases, just like it should for Offline Software validation. It should automatically report discrepancies with the previous release.

Plans/ToDo List

- Q: Should the triggers inherit all off-line improvements/changes automatically?
A: YES
- Q: How can we ensure that HLT can choose between adopting or rejecting changes when running on-line?
 - A: Run validation code with all new releases. This exercise will be the first indicator if improvements should be incorporated or rejected.

Performance of b-jet triggers

- Strategy to measure b-jet performance using the data
 - Same for both b-jet (lifetime or $b \rightarrow \mu$) HLT tag type
- Use a set of complementary HLT paths
- Measure performance in two diff ways
 - Generic HLT b-jet tag type performance
 - HLT b-jet performance with respect to an "offline b-jet" tag type.
- Provide b-jet HLT efficiency as a function of:
 - Jet PT
 - b-tag discriminator (lifetime) or μ - p_{Trel} ($b \rightarrow \mu$)

HLT b-jet performance

- For b-lifetime trigger:
 - Use the set e+jet HLT and e+b-jet HLT
 - Some basic differences between these will need to be put on an equal footing at the analysis stage
 - the e and b-jet pT requirement in e+b-jet HLT is lower (10, 35 GeV) than those (12,40) in e+jet
 - Level 1 jet pT (20 vs 30 GeV)

e + b-jet	A_IsoEG10_Jet20	(10, 35)	0.1 ± 0.0
e + jet	A_IsoEG10_Jet30	(12, 40)	11.6 ± 1.2

HLT b-jet performance

- For $b \rightarrow \mu$ tag trigger:
 - Use the set mu+jet HLT and mu+b-jet HLT
 - Some basic differences
 - Can equate at analysis level
 - the b-mu-jet pT requirement in mu+b-jet HLT is lower (20 GeV) than that (40) in e+jet
 - Compare the two sets to get the b-mu trigger performance

$\mu + b\text{-jet}$	A_Mu5_Jet15	(7, 35)	0.1 ± 0.0
$\mu + b \rightarrow \mu\text{-jet}$	A_Mu5_Jet15	(7, 20)	0.1 ± 0.1
$\mu + \text{jet}$	A_Mu5_Jet15	(7, 40)	6.3 ± 0.7

- The b-jet pT is 35 GeV
- Can use mu+jet vs mu+b-jet for b-lifetime tag as well.

Measuring performance...

- Then on the given set of trigger (ejet, e+b-jet) or (mujet, mu+b-mu-jet)
 1. run an offline b-jet tagger
 - then compare the offline tagged b-jet and see if the lifetime tagger has also selected this jet and extract the HLT b-lifetime tag efficiency
 2. Run the offline soft-lepton-tagger
 - then compare the offline tagged b-mu-jet and see if the HLT b-mu tagger has also selected this jet in order to measure the HLT b-mu-tag efficiency
- Can also do this on offline selected top quark samples.

Conclusion

- b/lifetime and b/ μ -jet triggers at HLT have been defined and are available for use.
- Code updates in 1.6.0(-pre4) are implemented.
- Validation suite needs to be improved and made part of the official suite
- Plans for measuring the b-jet performance from data and b-jet trigger turn on curves as a function of b-jet variables are being developed.