τ→3µ trigger

Andrey Korytov, Jian Wang (Univ. of Florida)

Joint Phase2 Muon Upgrade + L1 Trigger Workshop, 30/11/2018
Introduction

- \( \tau \rightarrow 3\mu \) with Phase-2 detectors was studied in early 2017, for the “Physics Performance” chapter of the Phase-2 Muon TDR
  - Design and software changes since then are not included
- This channel was used as a benchmark of the benefit from the extended coverage provided by ME0
  - ME0-CSC tandem was not studied; impact of GE1/1 neither (due to time constraint, or software not ready at that time)

\( \tau \rightarrow 3\mu \) features high eta, low momentum muon signature, because the major sources of tau at LHC are low mass B, D mesons
The muon detection fiducial volume is defined as $p > 2.5$ (not $p_T$), and $|\eta| < 2.4$ ($2.8$), for which the signal acceptance is $2\%$ ($4\%$).

- $p$ of the lowest momentum $\mu$, when all $3\mu$ have $|\eta| < 3$.
- $\eta$ of the most forward $\mu$, when all $3\mu$ have $p > 2.5$.

**ME0 doubles the acceptance**
Analysis overview

At reconstruction level, ME0 still doubles acceptance (TracerMuons are used)

Mass resolution is of course worse for events using ME0

Event categorization:

Category 1: None of the muons uses ME0
Category 2: At least one muon uses ME0

Event selections make use of displaced 3µ-vertex topology, muon ID, isolation, etc.

The background sample is QCD MC. PU = 200.
One station or two stations?

The probability to find a segment in ME1/1 or two segments in ME1/1&ME2/1 (MC muon gun study)

\[ \eta(\mu) = 2 \]

- Blue: Station1
- Red: Station1 & 2

A large fraction of reconstructed \( \tau \rightarrow 3\mu \) events looks like this.

p of the lowest momentum \( \mu \), reconstruction-level
Trigger strategy

Category one (without using ME0):

two L1 Mu + one muon stub, invariant mass < 3 GeV

- L1 Mu : L1 Track + STA muon or single muon segment (pT > 2 GeV, |eta| < 2.4)
- muon stub: assuming muon with p > 4 GeV can make a stub

Both signal and background (after final selections) have ~85% acceptance on these requirements (emulated by cuts on offline objects)

Rate guesstimation based on
Run 2 rate @1.3E34

L1_TripleMu0 10 kHz

Start from L1_TripleMu0 40 kHz @ 5E34
Track trigger & pT>2 GeV => a factor of 1/5
Invariant mass < 3 GeV => a factor of 1/20
=> 400 Hz at 5E34
Trigger strategy

Category two (at least one muon found by ME0):

one L1 Mu + two muon stubs, invariant mass < 3 GeV

Both signal and background (after final selections) have 
~50% acceptance on these requirements (emulated by cuts 
on offline objects)

Rate guesstimation based on 
Run 2 rate @1.3E34

- L1_TripleMu0 10 kHz
- L1_DoubleMu0 188 kHz

The ratio of L1_DoubleMu0 and L1_TripleMu0 is ~20

Apply this factor to the rate of category one on 
the previous page

=> 8 kHz @ 5E34
MC muon gun

eta (2.4, 2.8), where there is only ME0

Local x in Layer 1 - that in Layer 6 of SimHits

Note: if eta ~ 2.6

- $p/p_T \sim 6.7 \Rightarrow$ these muons are of $p_T \sim 0.5$-2 GeV
- The distance to the beamline ~ 80 cm
  $\Rightarrow d\phi = dx/80$
Discussion

- $\tau \rightarrow 3\mu$ is a user case; meanwhile, low momentum multi-muon signature could be of general interest
- Beneficial to have L1 Track + Mu stub (Vladimir’s talk yesterday)
  - Not easy, but stubs become super-stubs in Phase 2
  - Can ME0-ME1/1 and GE1/1-ME1/1 tandems do the job of ME1/1-ME2/1 two-station tandems?
- Event better to have ME0-only stubs (for $\eta > 2.4$) at trigger level. The rate could be under control, if it is used in a multi-object trigger
Backup
Category 2