τ->3μ trigger

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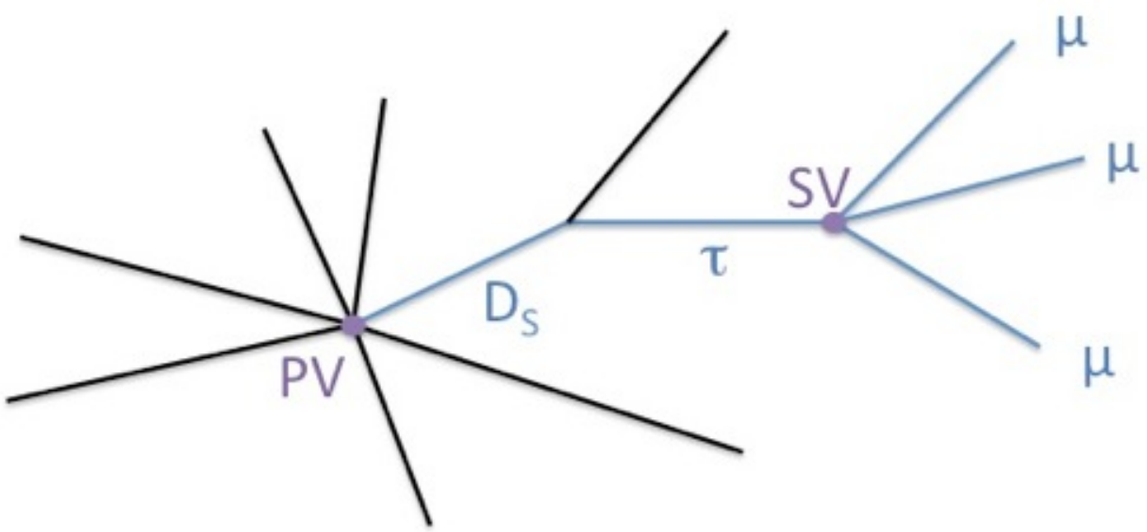
Introduction

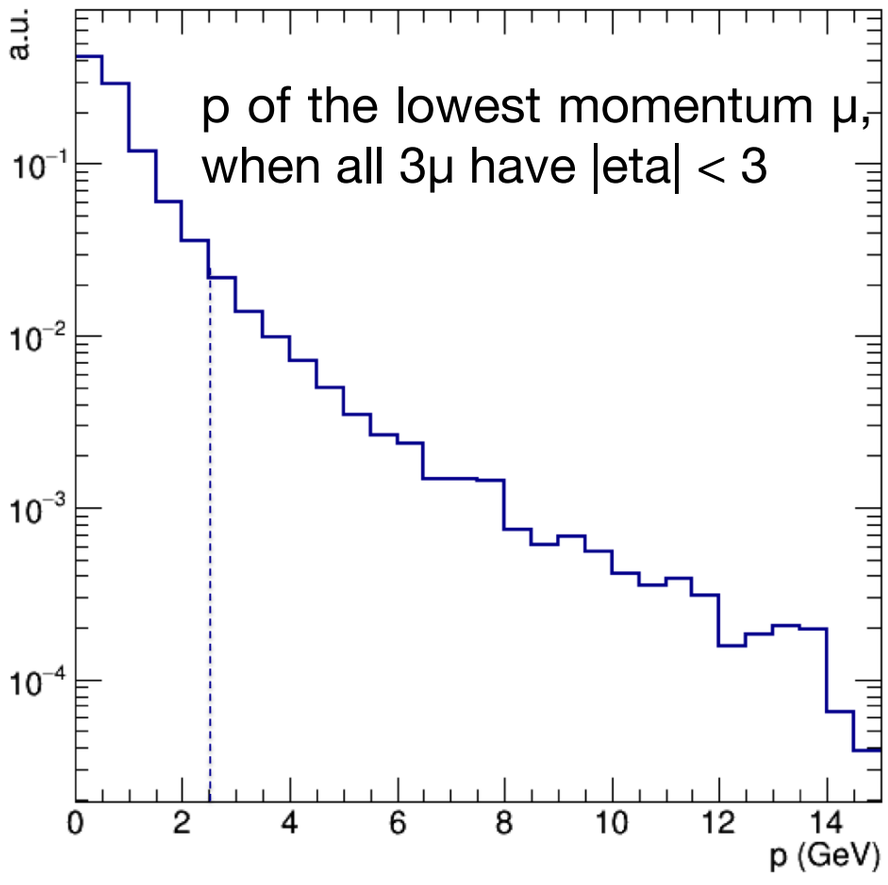
- τ->3μ with Phase-2 detectors was studied in early 2017, for the "Physics Performance" chapter of the Phase-2 Muon TDR
  - Design and software changes since then are not included
- This channel was used as a benchmark of the benefit from the extended coverage provided by ME0
- ME0-CSC tandem was not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

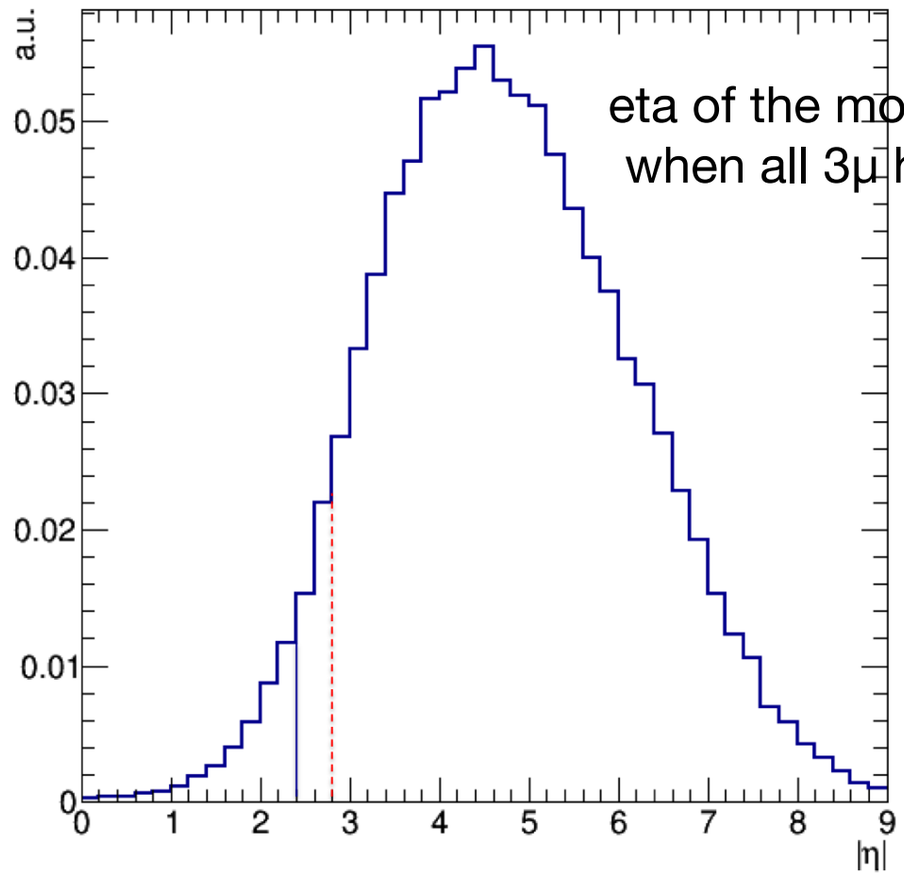


τ->3μ features high eta, low momentum muon signature, because the major sources of tau at LHC are low mass B, D mesons

Generator-level signal acceptance

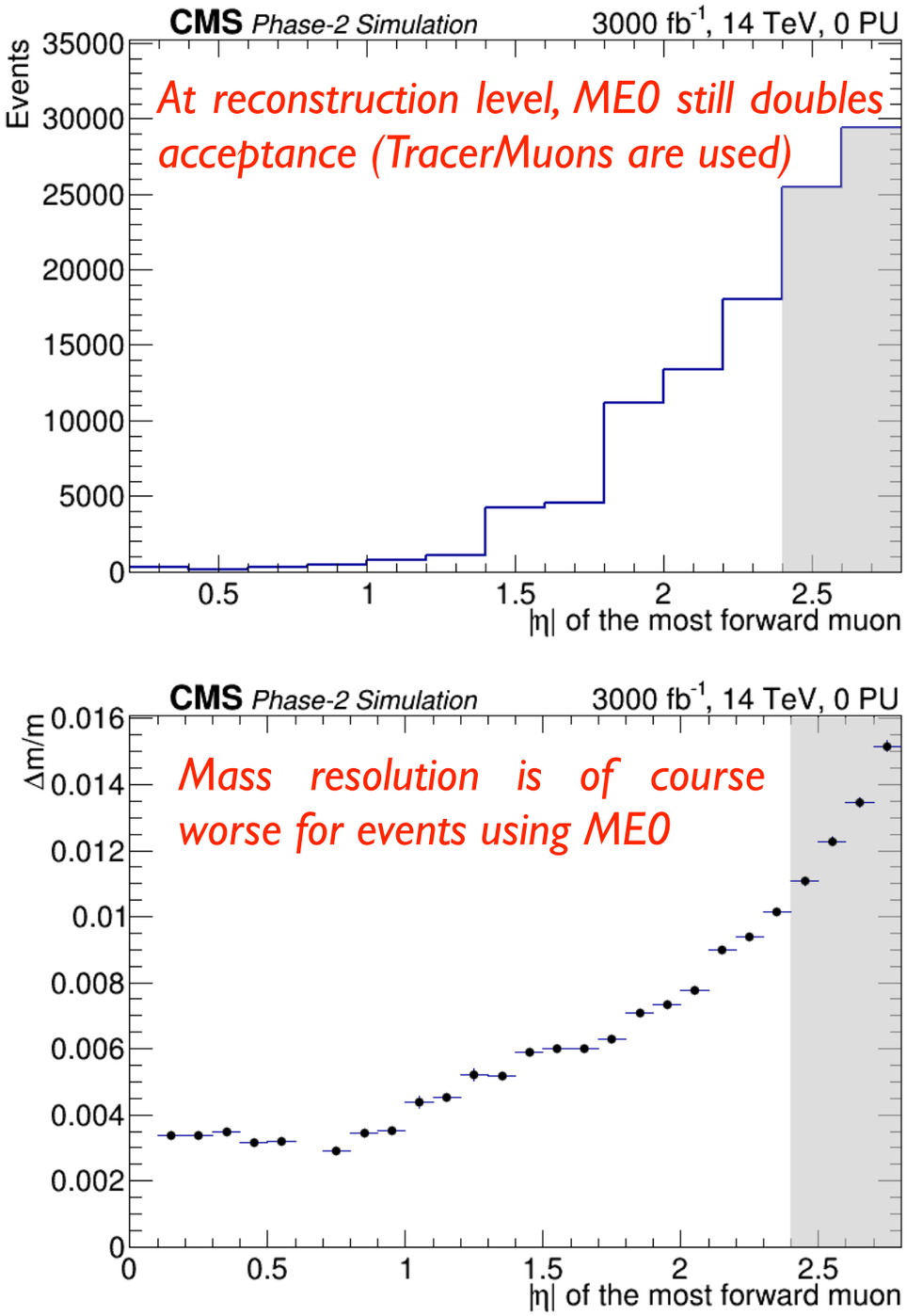
The muon detection fiducial volume is defined as p > 2.5 (not pT), and |eta| < 2.4 (2.8), for which the signal acceptance is 2% (4%)





ME0 doubles the acceptance

Analysis overview



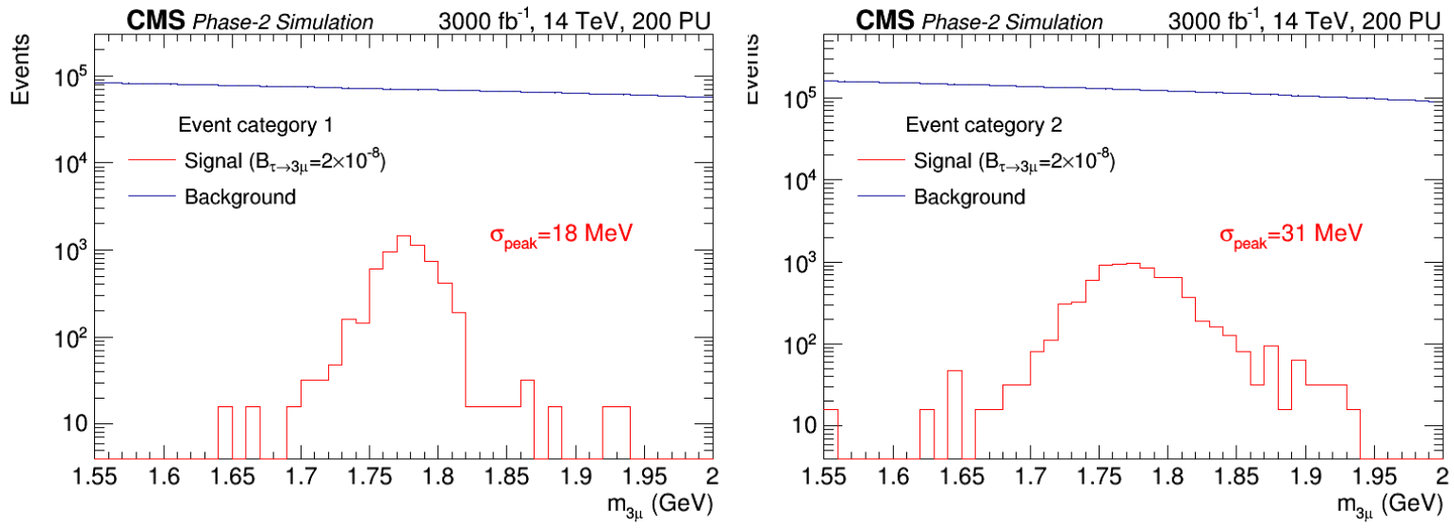
Event categorizatoin:

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.

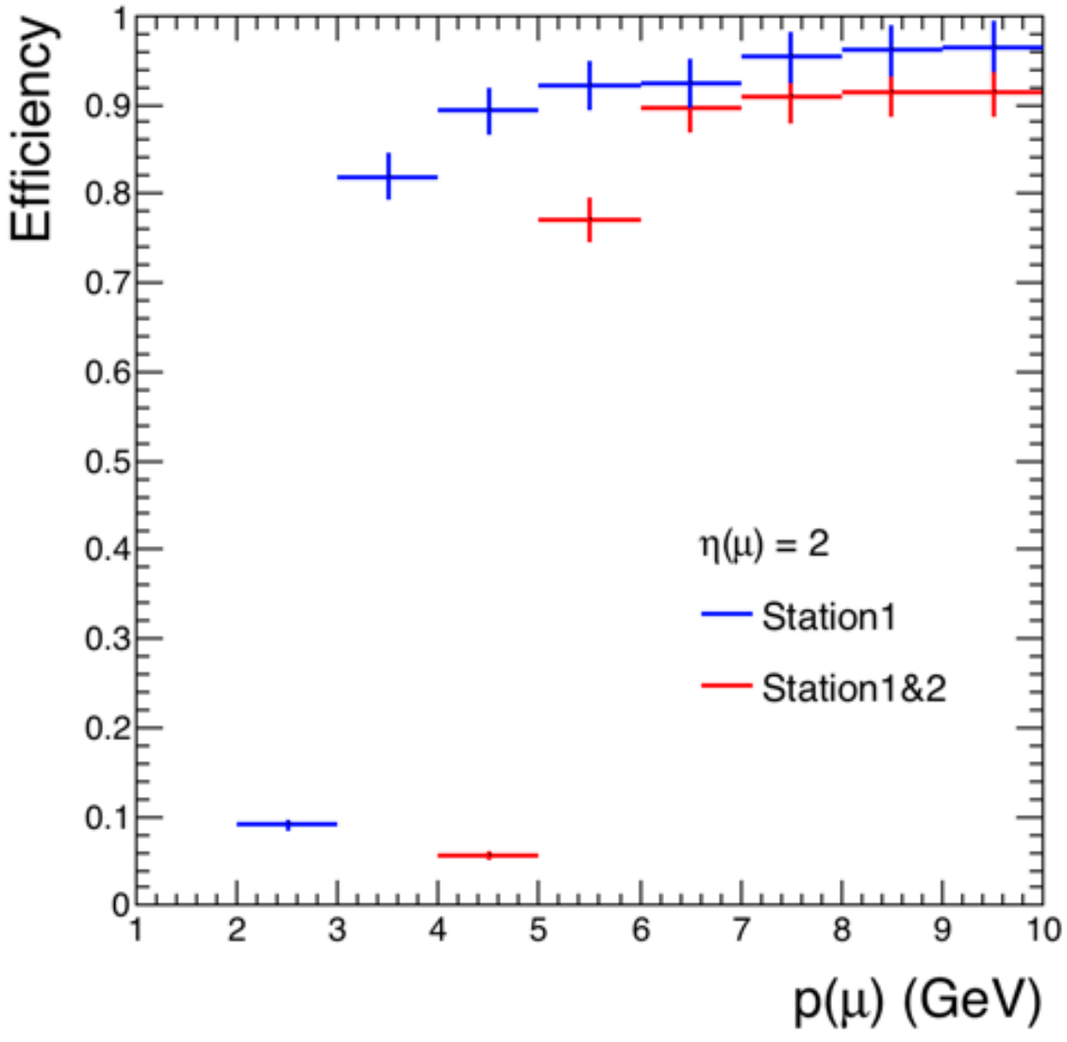
The background sample is QCD MC. PU = 200.

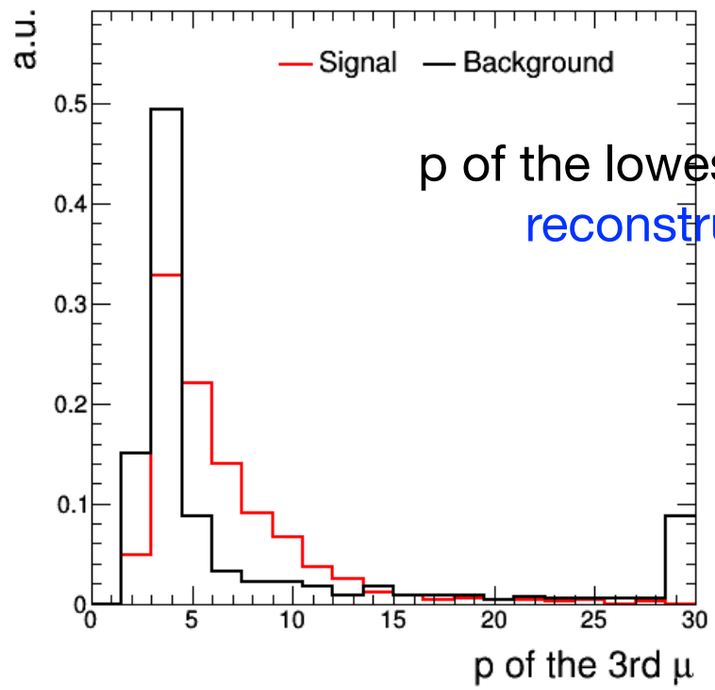


Number of events in mass window 1.55–2.00 GeV	Category 1		Category 2	
	sig	bkg	sig	bkg
Final selection before the trigger	6 130	3.2×10^6	7 810	5.6×10^6

One station or two stations?

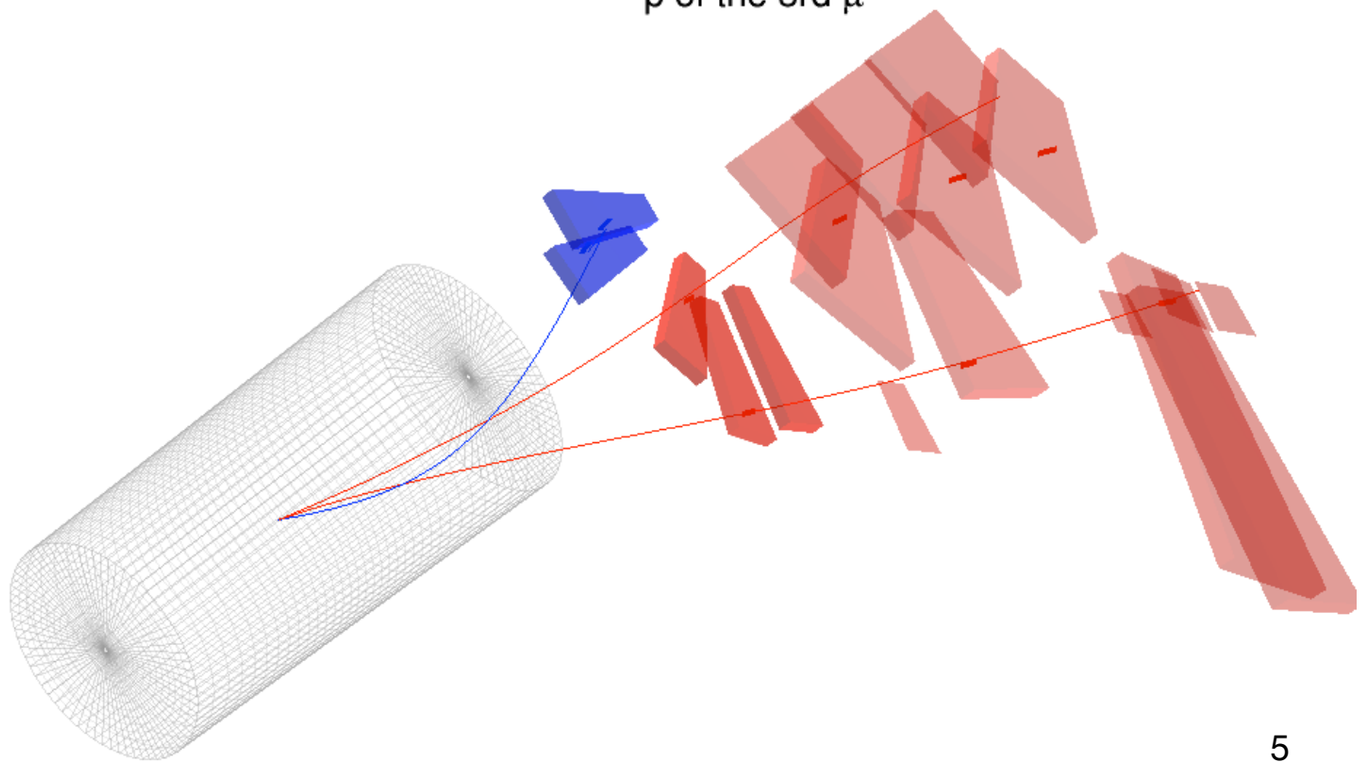
The probability to find a segment in ME1/1 or two segments in ME1/1&ME2/1 (MC muon gun study)





p of the lowest momentum μ, reconstruction-level

A large fraction of reconstructed τ->3μ events looks like this



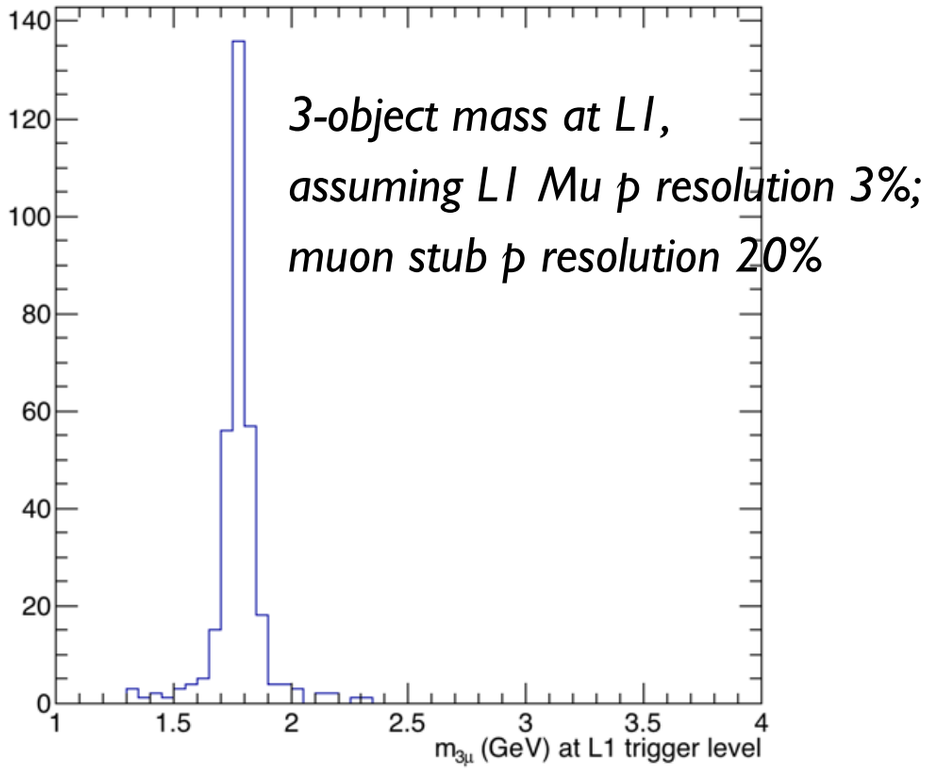
Trigger strategy

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

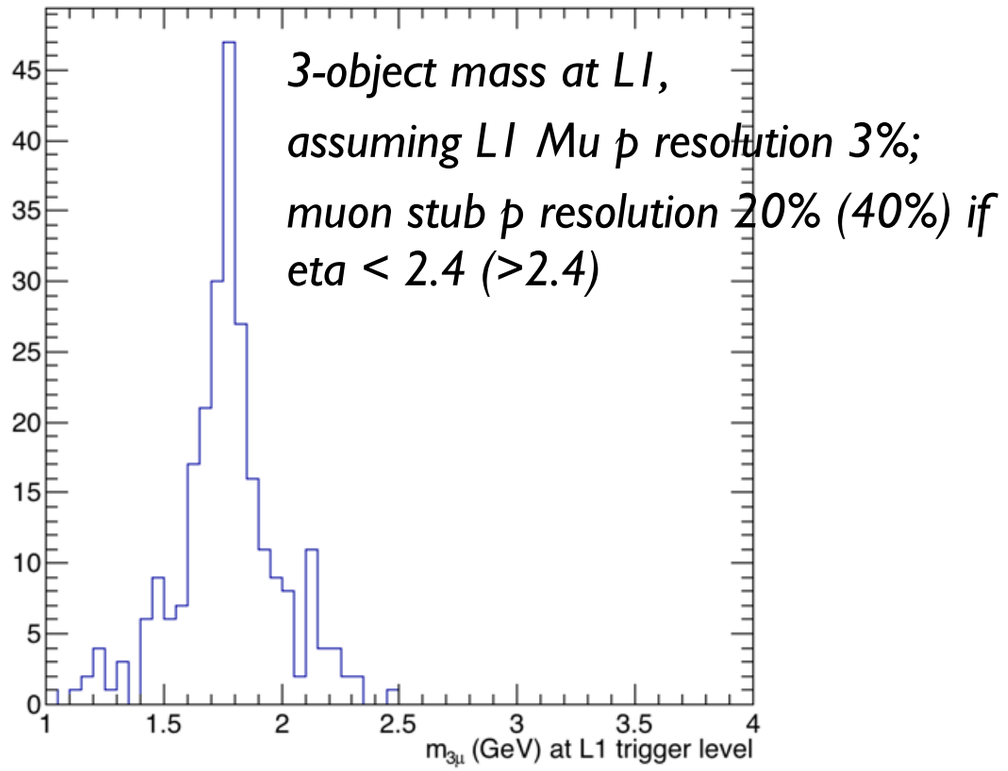
=> 400 Hz at 5E34

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

Muon bending in ME0

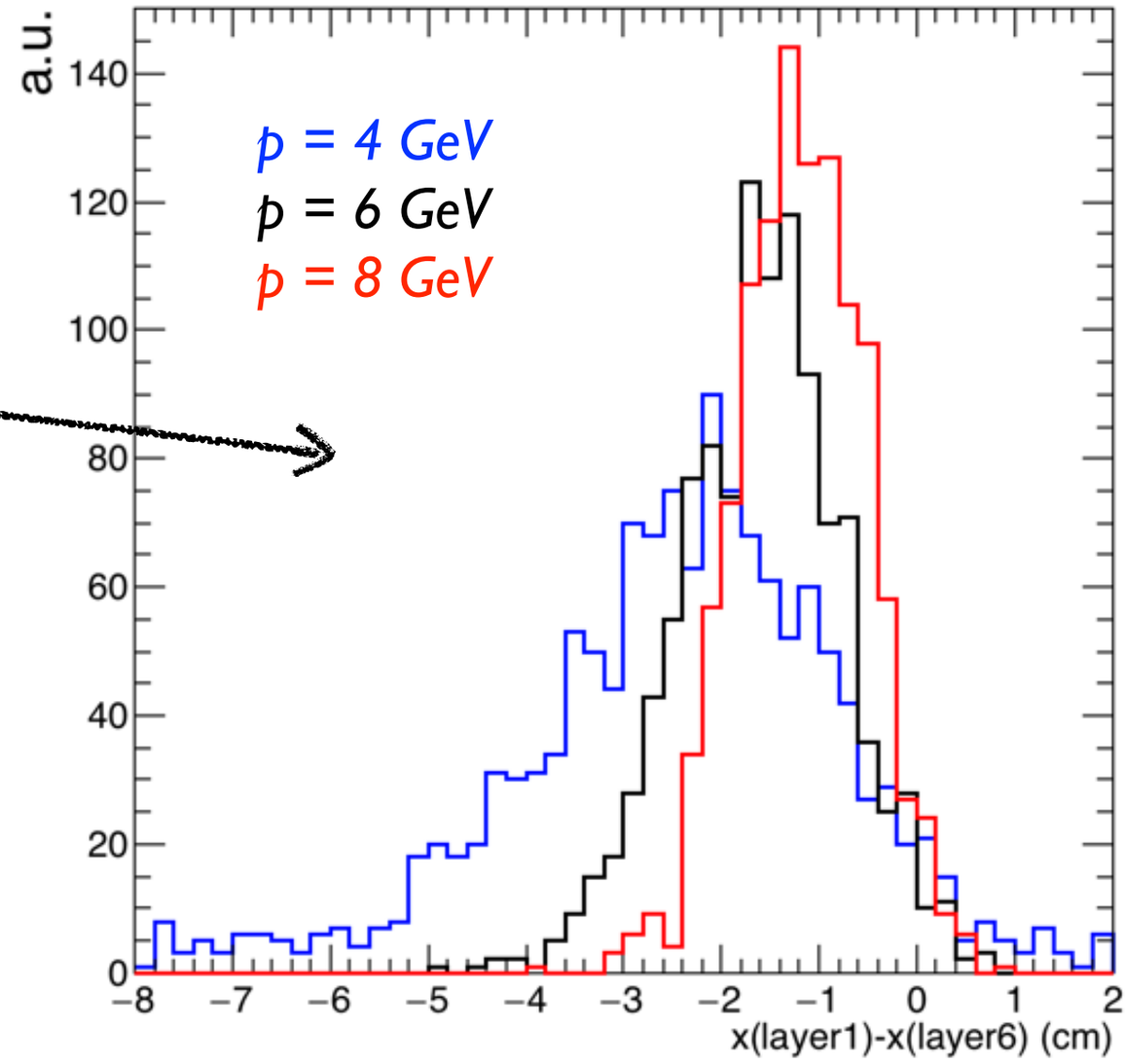
MC muon gun

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

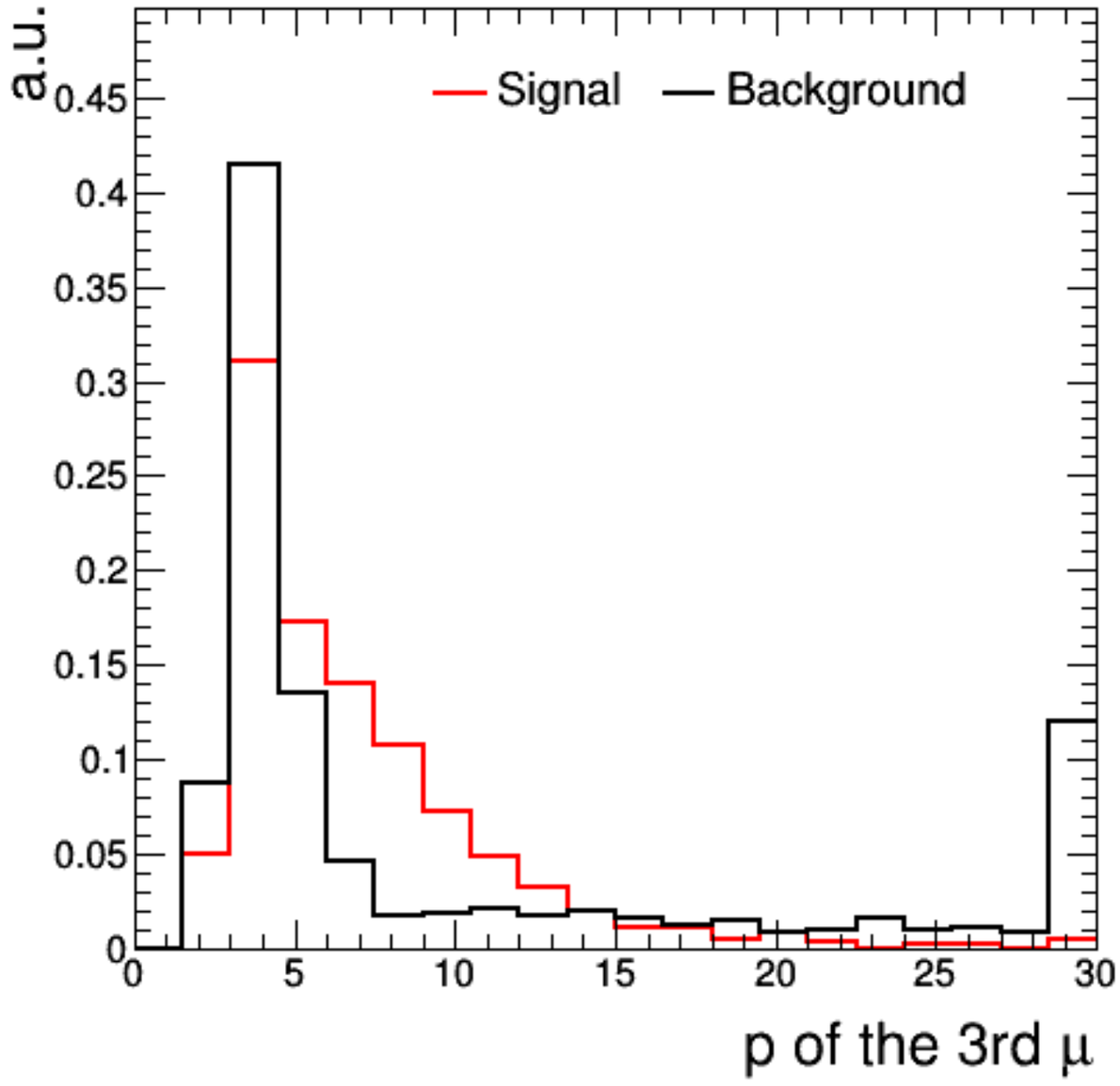
- p/pT ~ 6.7 => these muons are of pT~ 0.5-2 GeV
- The distance to the beamline ~ 80 cm => dphi = dx/80



Discussion

- τ->3μ 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


a.u.
Signal
Background
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
p of the 3rd μ

Category 2