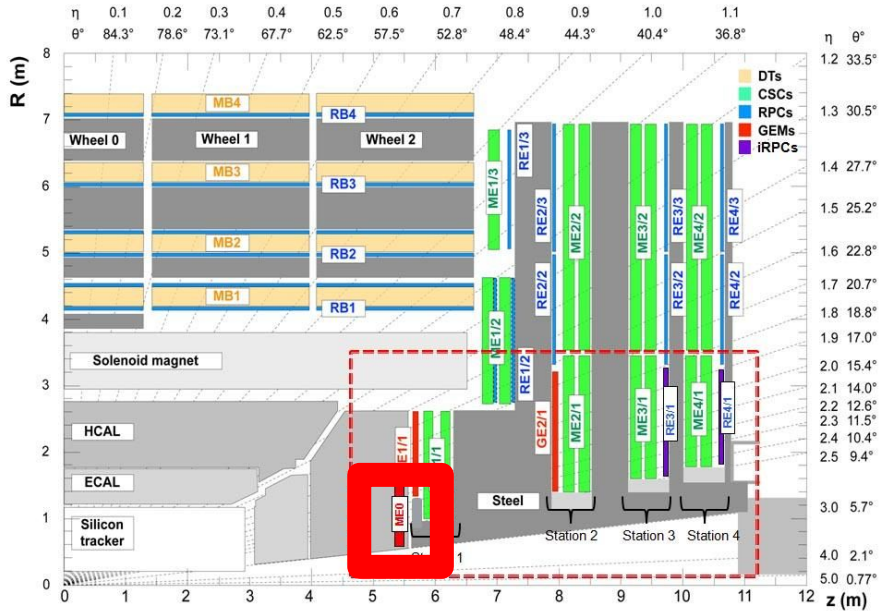


# ME0 stand-alone trigger

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for the ME0 Group

# The ME0 station

- Multi-layered structure: **6 layers** of triple-GEM detectors along z (instead of 2 layers, like the other GEM stations)
- Eta coverage:  $2.0 < |\eta| < 2.8$ 
  - overlapping with existing muon stations up to  $|\eta| < 2.4$ 
    - GEM+CSC combined muon trigger at  $|\eta| < 2.4$
  - the only muon station at  $|\eta| > 2.4$ 
    - ME0-only trigger, not possible to combine with other muon stations to trigger a single muon
- changes with respect to TDR:
  - HGCAL  $1\lambda$  reduction + reduction in ME0 shielding
  - possible impact on ME0



# Triggering in $2.4 < |\eta| < 2.8$

## Level-1: L1-trigger

Coarser information ( $1/2 \phi$  granularity) is read out every BX for participation in L1-trigger

## Level-2: More precise measurement

Full detector granularity for more precise momentum measurement

Can subsequently seed regional pixel tracking early in HLT

With L1 track trigger restricted to  $|\eta| < 2.4$ , necessary for muon track pixel reconstruction

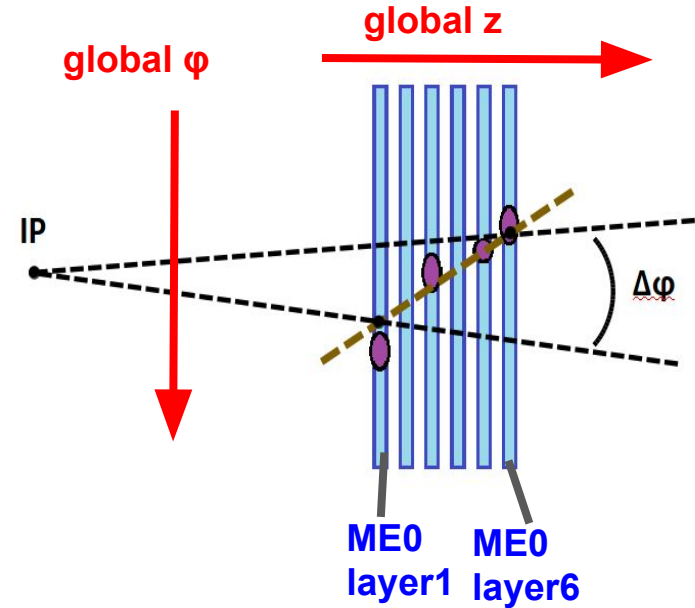
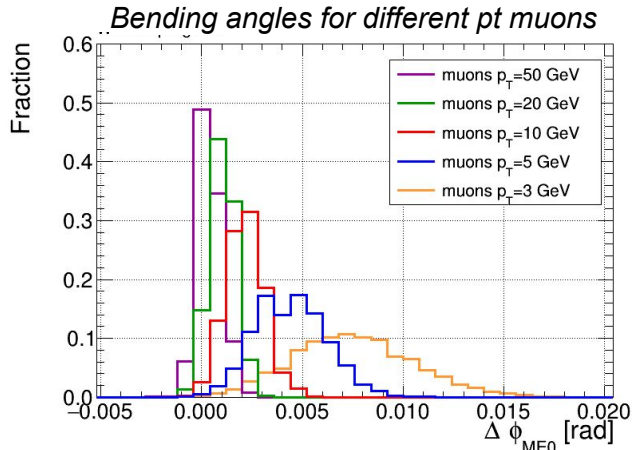
## HLT: Full reconstruction

Full granularity ME0Segments matched to pixel tracks

Precise muon ID: matched pixel track for ~offline reconstruction (e.g. superior momentum measurement, vertex assignment)

# Muon reconstruction (stand-alone)

- A muon traversing an ME0 chamber is detected:
  - ~75% in 6 layers
  - ~18% in 5 layers
  - ~7% in 4 layers
- The muon  $p_t$  is evaluated from the bending angle, defined as the difference in the global phi ( $\Delta\phi$ ) between the position on layer6 and on layer1 of the straight line fit



(distances not to scale)

# L1 Trigger in $2.4 < |\eta| < 2.8$

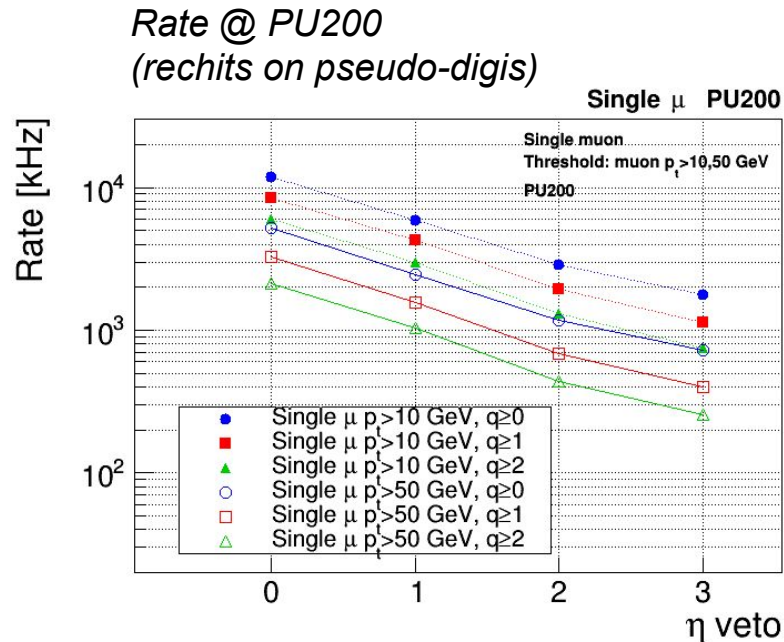
High L1-trigger rates on single muons:

- ME0Segment multiplicity too large for single muon trigger
- estimated  $\geq 200$  kHz for muons with  $p_t > 50$  GeV
- worse at smaller  $p_t$

## Possible options:

- A) Cross-triggers (for specific analyses)
- B) Multi-stubs in ME0 (for specific analyses)
- C) Pixel+ME0 combined trigger (at L1 level)

Rate reduction is a primary issue



# Cross-triggers example: $Z \rightarrow \mu\mu$

thanks to N.McColl

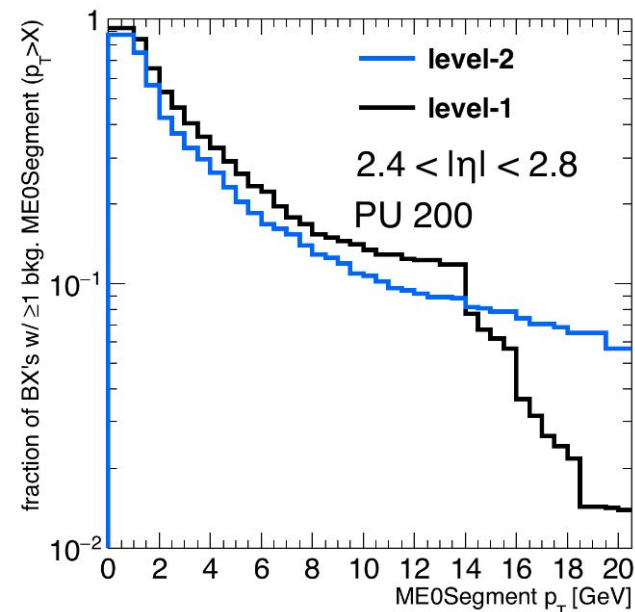
$Z \rightarrow \mu\mu$  with **one**  $2.4 < |\eta| < 2.8$  muon

Look for  $p_T > 6$  GeV ME0Segments w/ correct charge (based on  $|\eta| < 2.4$  muon charge):

- $> 95\%$  ME0 reconstruction efficiency
- Factor of  $\sim 10$  reduction in bkg. events
- trigger rate estimate N/A

Reco. efficiency:

	Segment reco.	correct charge	$p_T > 6$ GeV
Level-1	99.3%	98.7%	95.7%
Level-2	99.6%	99.3%	97.7%

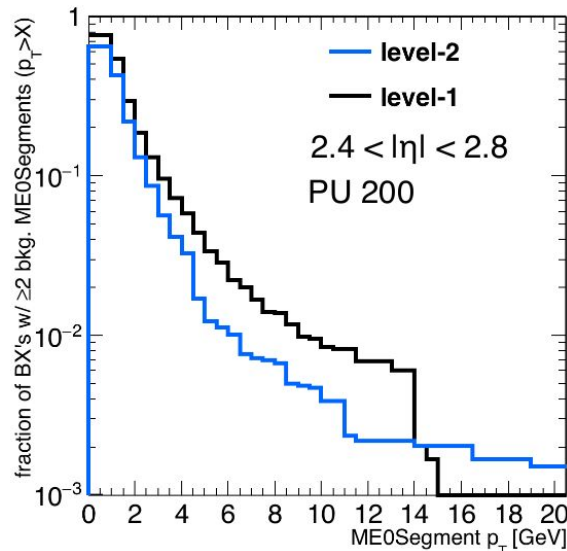


# Multi-stubs in ME0 example: $Z \rightarrow \mu\mu$

$Z \rightarrow \mu\mu$  with **two**  $2.4 < |\eta| < 2.8$  muons

Look for two  $p_T > 6$  GeV ME0Segments w/ opposite charge  
(Low sample statistics)

- ~95% ME0 reconstruction efficiency
- Factor of ~100 reduction in bkg. events
- trigger rate estimate N/A

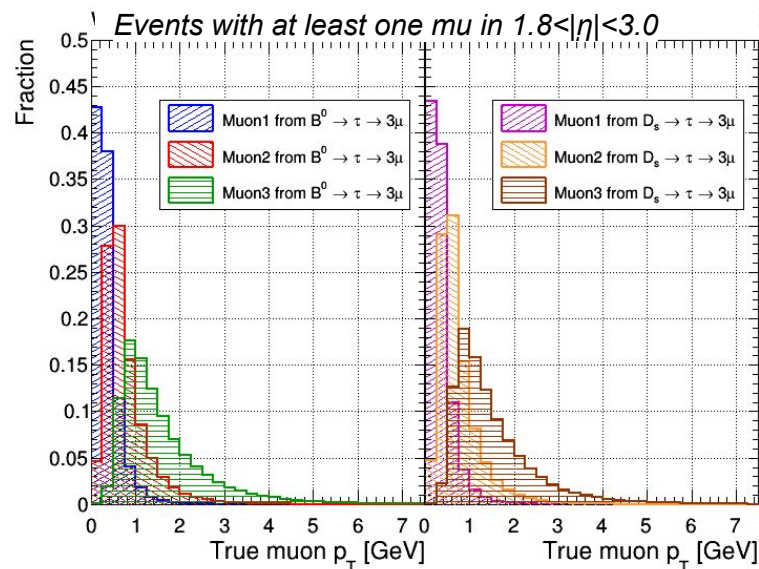


Reco. efficiency:

	Segment reco.	correct charge	$p_T > 6$ GeV
Level-1	99%	98%	94%
Level-2	97%	97%	95%

# Multi-stubs in ME0

- use **segments** as part of multi-object **triggers**
- in the whole **ME0 coverage**  $2 < |\eta| < 2.8$
- interesting for events with very boosted final muons
  
- example:  $\tau \rightarrow 3\mu$   
muons to trigger in ME0 have very low  $p_T$  (few GeV)

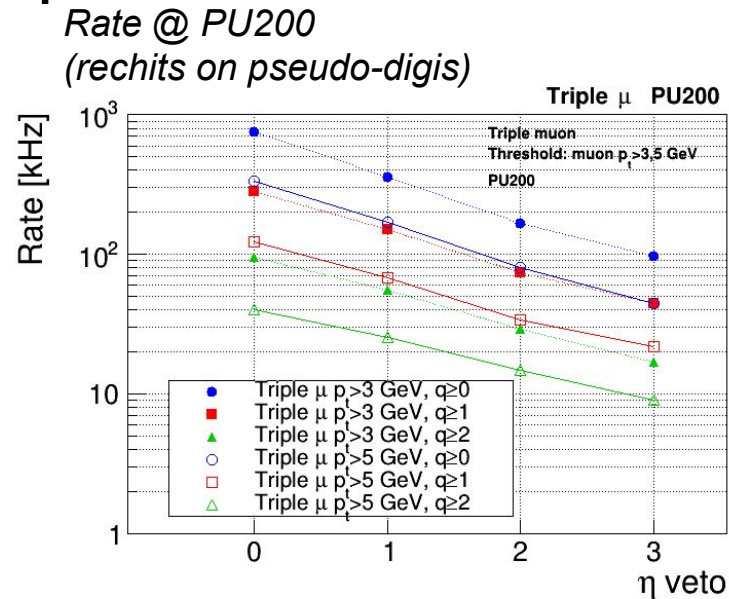




# Multi-stubs in ME0 example: $\tau \rightarrow 3\mu$

Select at least 3 segments in ME0  
to satisfy the  $\Delta\phi$  (pT) threshold  
and in same/nearby chambers

- e.g. 300-900 kHz for  
3 segments with  $p_T > 3$  GeV  
high increase in trigger rate reducing the  
pt thresholds
- need to study additional constraints to  
reduce threshold and gain in signal efficiency, e.g.
  - impose an invariant mass cut to reduce rate
  - impose constraint on sum of segment signs =  $\pm 1$
  - study possibility to include Pixel detector into combined Pixel+ME0 L1 trigger  
to reduce trigger rates and improve pT resolution  
→ see talk on Friday



# Trigger primitives

- The trigger primitives for the L1 (standalone) trigger of the ME0 station is not decided yet
  - baseline: use hit patterns to compare with LookUp Tables like CSCs → no study existing yet for ME0
  - other options can be proposed, alternatives can be  $\Delta\phi$ , muon pt

## **Possible variables** provided by the ME0 station:

- eta (eta partition) and global phi of the hit on layer1
- $\Delta\phi$
- muon pt
  - lower threshold for the muon pt
- sign of the segment
  - from the sign of the bending angle
- quality of the segment
  - number of rec. hits used to build the segment
  - from the quality of the fit of the straight line, e.g.  $\chi^2$
  - timing pattern (BX of hits used for the segments)
  - presence of dirty segments associated with the segment