Muon trigger architecture

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Joint P2 Muon Upgrade + P2 L1 Muon Algorithms workshop
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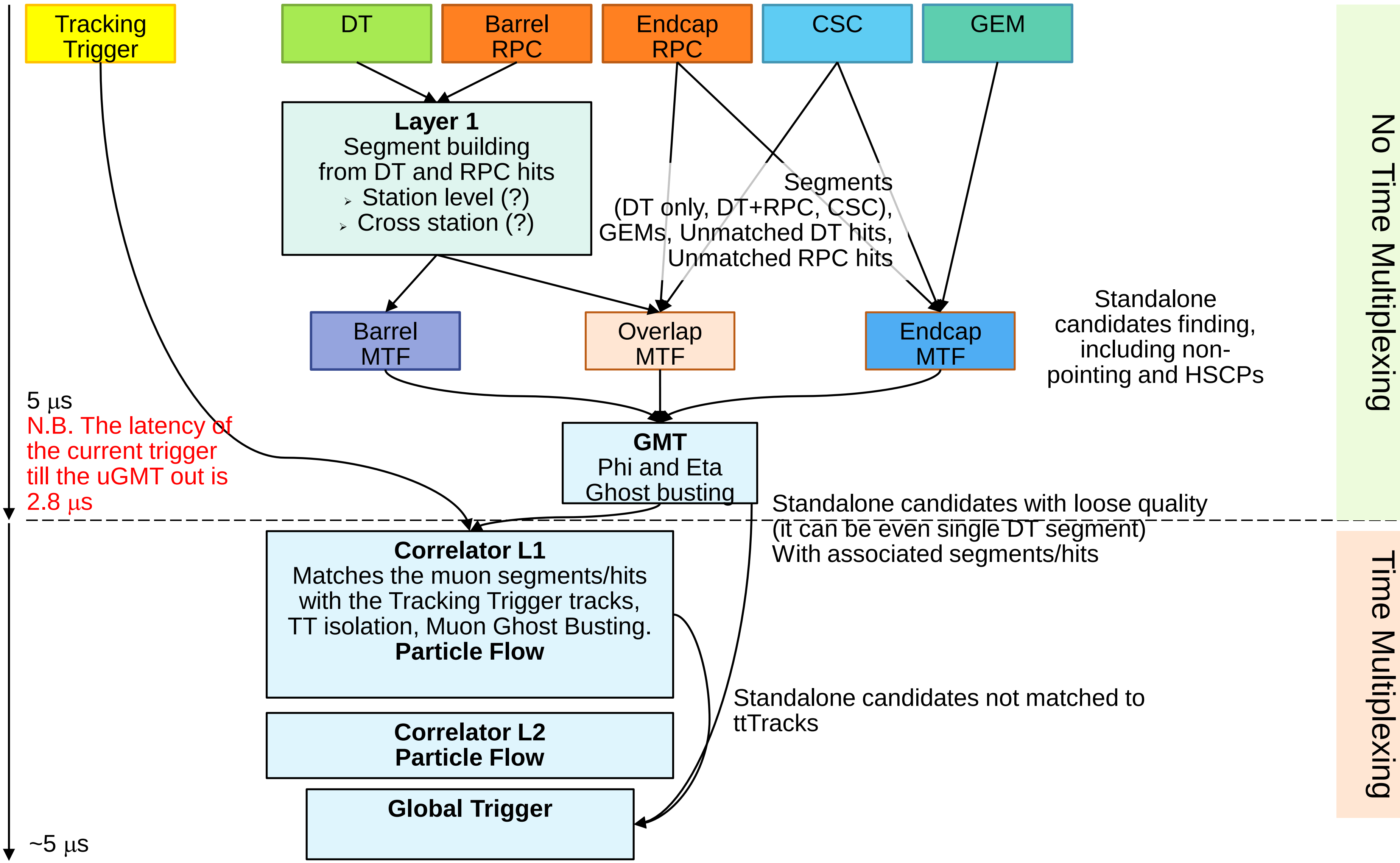
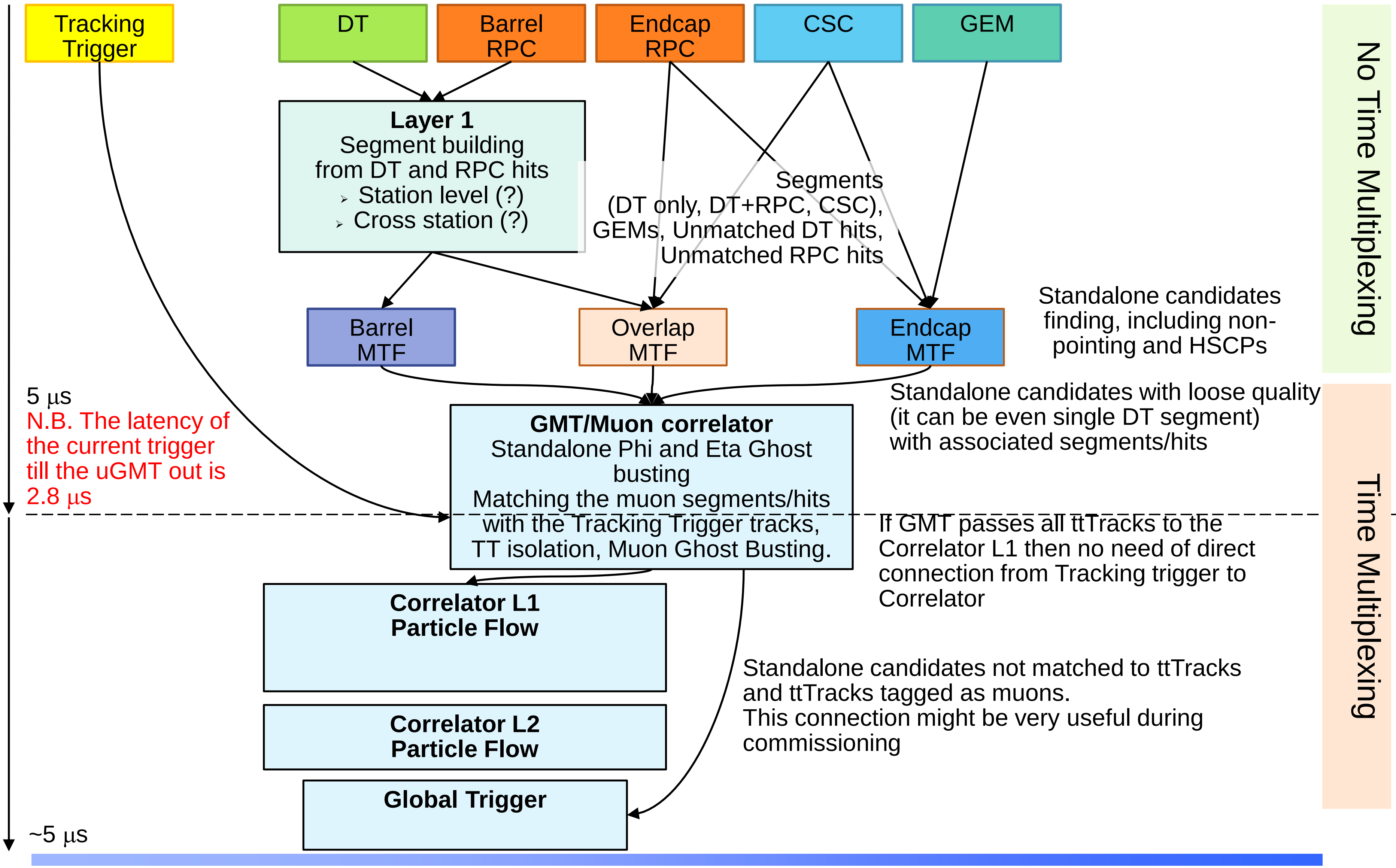
Muon Trigger architecture, version 1a



Muon Trigger architecture, version 1b



Muon trigger algorithm draft version 1

Goal: do as much as possible before matching to the ttTracks - to reduce the latency

1. **Build trigger primitives**
   a) Barrel: layer based DT+ RPC,
      if BX identification not unique, sent to the Track Finders all reasonable segments (TF will clean them correlating with other layers).
      Sent to the TF not matched RPC or even DT hits
   b) Endcaps?
2. **Track Finders – no TM**
   a) Build standalone muon candidates including displaced and HSCPs. To maximise the efficiency allow for “wide roads”. Single layer (high quality) DT(+RPC) segment also threaded as standalone candidate
   b) For every standalone candidates in each layer at most **one** hit/segment should be assigned (this will simplify significantly the step 3c). If this requirement affect the performance, **two** hits/segments can also be allowed.
   c) Assigne standalone phi, eta, pT, charge, d0, BX
   d) Send the standalone candidates and associated hits/segments to the GMT/correlator
3. **GMT/correlator – TM**
   a) Standalone candidates eta and phi ghostbusting
   b) Coarse matching of the ttTracks to the standalone muon candidates – extrapolate the ttTrack to the muon system (based on ttTrack pT, charge, eta, phi) and select the standalone candidate that has compatible phi and eta (standalone muon pT measurement ignored).
      NB. One extrapolation for every ttTrack, therefore the logic should be as simple as possible.
   c) Fine matching of the selected ttTrack to the hits/segments of the matched standalone candidate.
   d) Ghost busting: choosing the ttTrack that fits best to given standalone candidate hits/segments.
   e) ⇒ each ttTrack is tagged as muon or not (pT, charge, eta and phi taken from the ttRack), the standalone candidates not matched to any ttTrack become displaced candidates

Version 1b – TF-GMT link and GMT board count

- Hit/segment global coordinates:
  - Phi: ~14 bits
  - phiB: ~10 bits
  - Eta: ~10 bits
  - Layer/station: 3 bits
  - Sublayer or z: 2 bits
  - Quality: 3 bits

  ~42 in total

  Assuming let's say 8 hit/segments per standalone muon candidate = 336 bits

  standalone muon coordinates: ~40 bits for eta, phi, pT

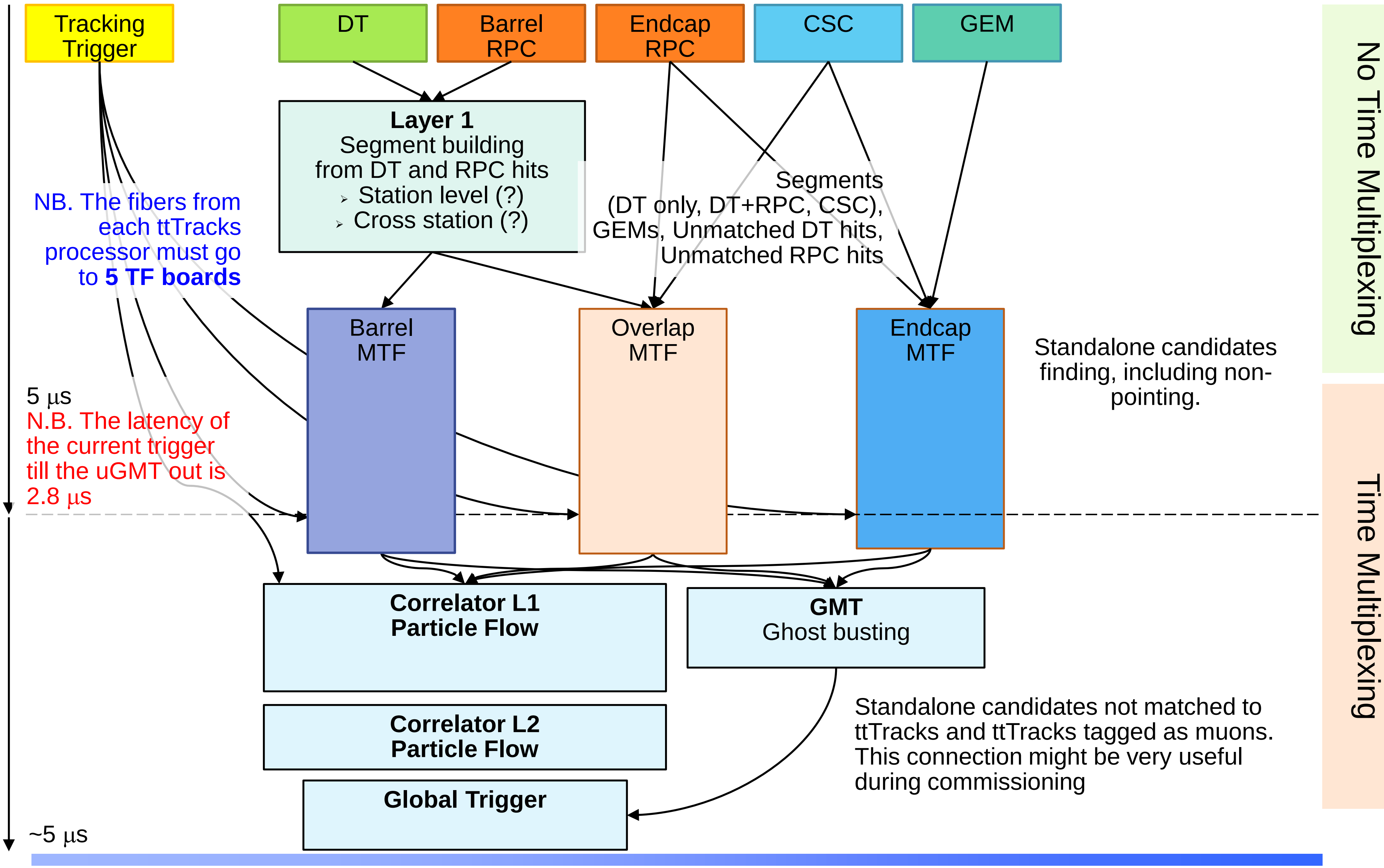
  Everything just fits in data transmitter by 1 link during 1 BX:

  Links 16 Gbps 64b66b = 384 bits /bx

  $\Rightarrow$ **One link from one Track Finder board can transmit up to n candidates and its hits/segments, where n is TM factor – much more then needed.**

- One GMT board receives then 36 links from TF (assuming the same number of boards as now) and 18 links from Tracking Trigger (2 links from each nonant) - assuming TM18.
  Then 18 GMT boards needed.
  But probably this can be reduced to 9 boards – assuming one TF-GMT link transmits data from 2 Bxes (total number of links 18+18+36)

Muon Trigger architecture, version 2



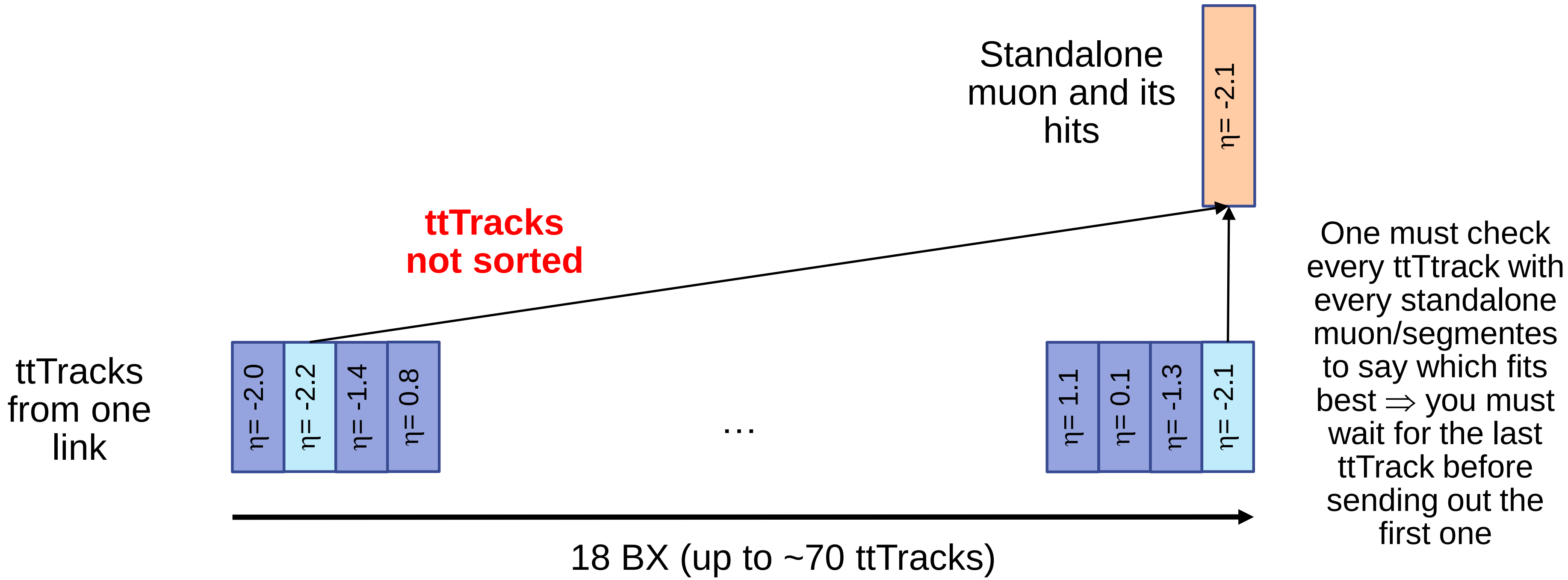
Muon trigger algorithm draft version 2

1. **Build trigger primitives**
   a) Barrel: layer based DT+ RPC,
      if BX identification not unique, sent to the Track Finder all reasonable candidate segments (TF will clean them correlating with other layers).
      Sent to the TF not matched RPC or even DT hits
   b) Endcaps?
2. **Track Finders, ttTrack correlation – TM, one board for full phi, but system still segmented in eta.**
   a) Build standalone muon candidates including displaced and HSCPs. To maximise the efficiency allow for “wide roads”. Single layer (high quality) DT(+RPC) segment also threaded as standalone candidate
   b) For every standalone candidates in each at most layer **one** hit/segment should be assigned (this will simplify significantly the step 3c). If this requirement affect the performance, **two** hits/segments can also be allowed.
   c) Assigne standalone phi, eta, pT, charge, d0, BX
   d) When ttTRacks arrive: coarse matching the ttTracks to the standalone muon candidates – extrapolate the ttTrack to the muon system (based on ttTrack pT, charge, eta, phi) and select the standalone candidate that has compatible phi and eta (standalone muon pT measurement ignored).
      NB. One extrapolation for every ttTrack (a few hundreds per BX), therefore the logic should be as simple as possible.
   e) Fine matching of the selected ttTrack to the hits/segments of the matched standalone candidate.
   f) Ghost busting: choosing the ttTrack that fits best to given standalone candidate hits/segments.
   g) $\Rightarrow$ each ttTrack is tagged as muon or not (pT, charge, eta and phi taken from the ttTRack), the standalone candidates not matched to any ttTrack become displaced candidates
   h) Send the tagged ttTracks to the Correlator and GMT, send standalone displaced candidates to the GMT
3. **GMT – TM**
   a) Standalone and tagged ttTracks eta ghostbusting – needed to kill the standalone candidates found by the neighbouring Track Finders.

N.B. The need of tagged ttTracks ghostbusting between the track finders (i.e. in eta) can be avoided, if the ttTracks are sent to the Track Finders with sufficient overlay (~size of the W±2)

Remarks – latency

- If the ttTrack coming from one nonant are sorted by eta, then the latency of the ttTracks to muons matching can be reduced – one does not have to wait for the last ttTrack from given BX to finalise the ghostbusting, i.e. one can send out the first ttTracks from the BX even before the last arrived



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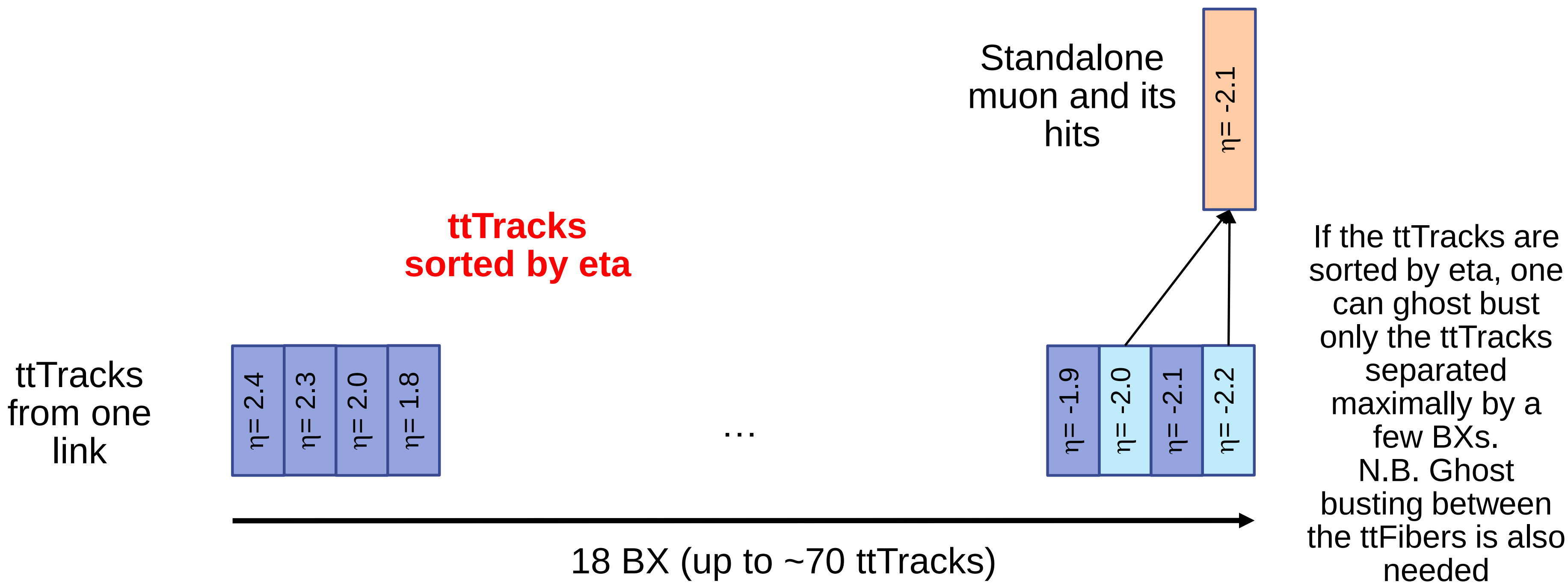


Total latency contribution: transmission: ~6BX, matching and ghostbusting: ~6BX, waiting with ghostbusting ~6BX

Remarks

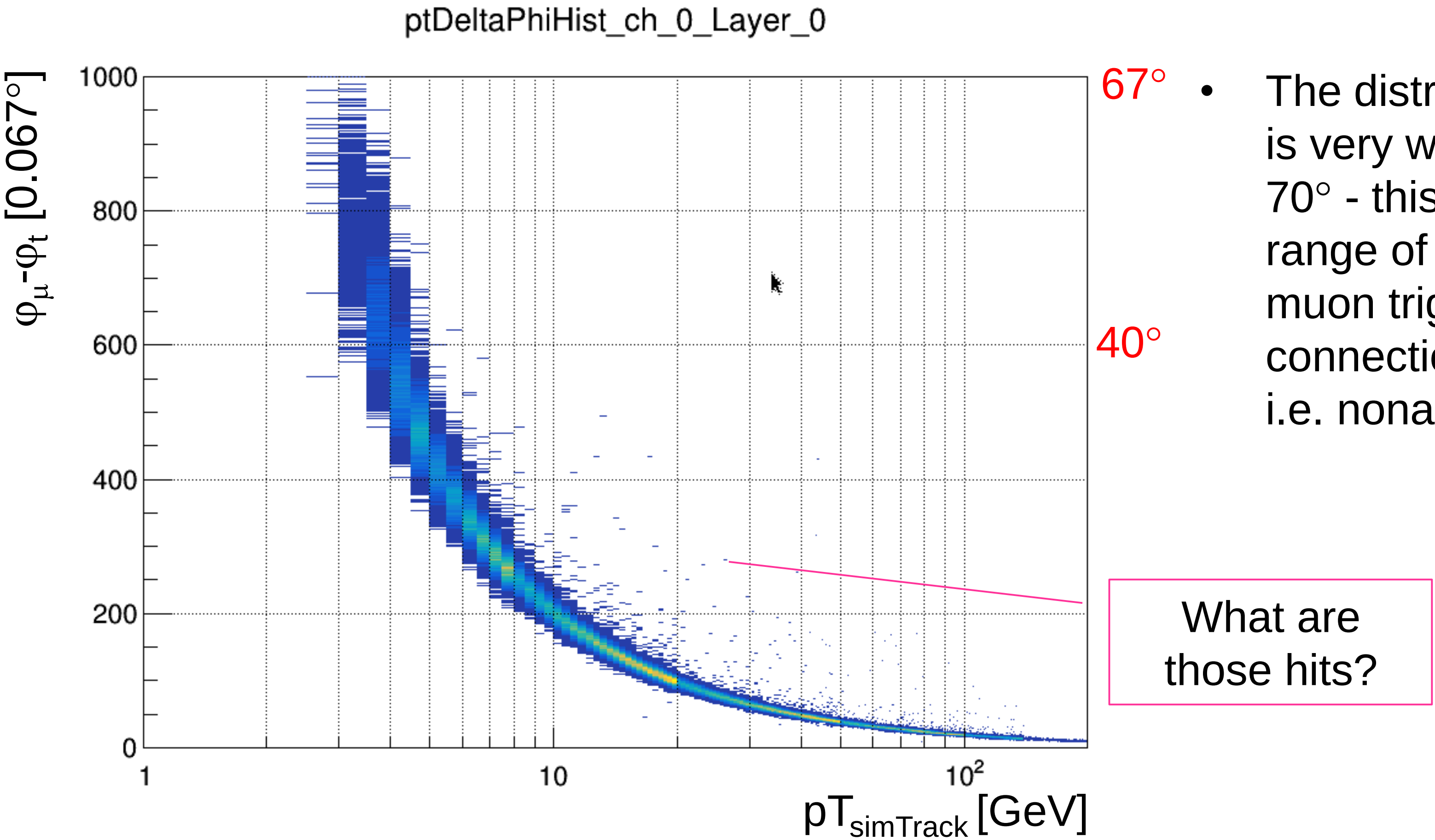
- Bendnig of low pT tracks from vertex to the first muon station is up to 70° ⇒ the ttTracks from one nonant of the tracking (i.e. 40°) trigger must be merged with the muon segments/hits from 180° ⇒ the ttTrack merging with the muon segments/hits should not be divided between boards in phi.

- The ttTracks tagging as muon should be as efficient as possible even for very low pT tracks, otherwise significant fraction of these low pT muons will be recognised as displaced muon (since not matched to ttTrack).

- Fake tagging of very low pT ttTrack as a muon can reduce efficiency for displaced muons.
  Otherwise is in principle not harmful (for the ttTracks below the lowest muon threshold) – provided for the particle flow the low pT tracks are not very important.

Backup

φ_μ-φ_t for DT MB1



- The distribution of φ_μ-φ_t is very wide – almost 70° - this indicated the range of the TT to the muon trigger connections (TT sector i.e. nonant is 40°)

- Plot obtained from the OMTF emulator: φ_μ-φ_t is in the OMTF scale (i.e. the unit is CSC half-strip)

L1 Trigger latency, end of 2017