Update on HO-DT trigger studies

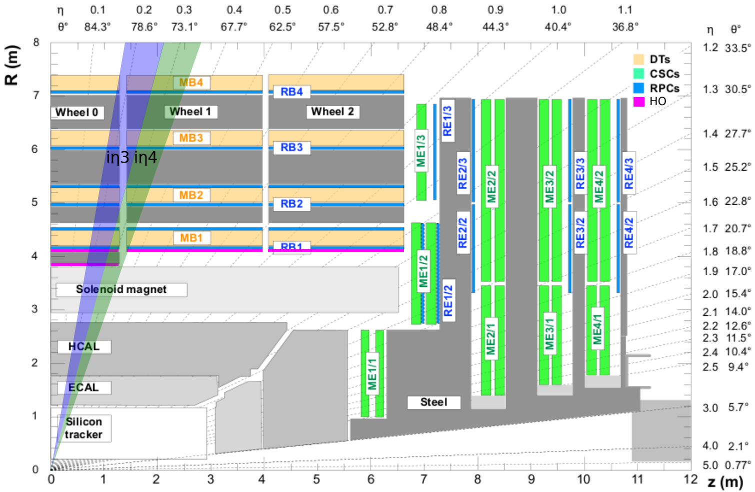
Soham Bhattacharya[1]   Ashraf Mohamed[2]

[1]TIFR, Mumbai, India

[2]DESY

MB1+HO: Geometry [1]

HO tile dimension is 0.087 × 0.087 in $\eta \times \phi$, except in $i\eta 4$ where it is ∼half in η.



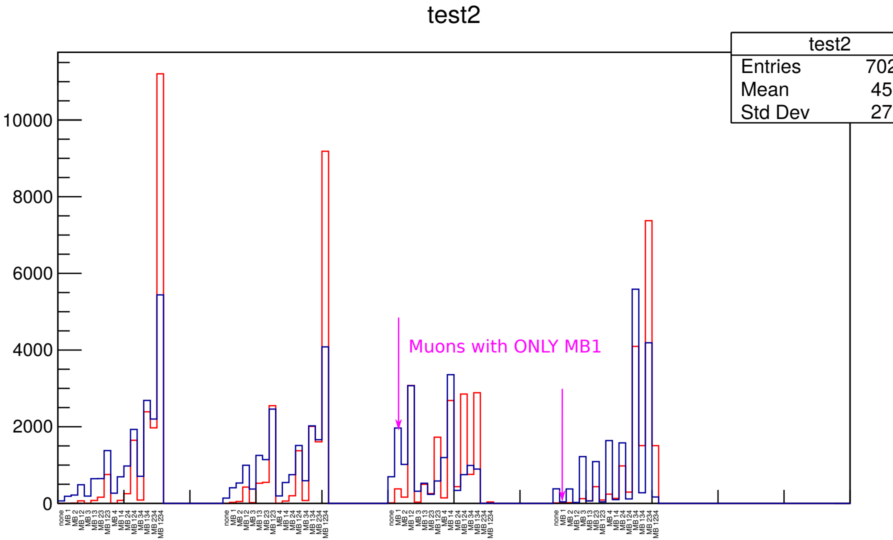
MB1+HO: Geometry [2]

- Had initially expected MB1+HO to be most useful in $i\eta 4$.
- The following slides on DT gap study lead to the conclusion that it is in fact $i\eta 3$.

- **Sample:** `/SingleMuon/Run2017C-ZMu-PromptReco-v3/RAW-RECO`
- Tight muons with $p_T > 30$ GeV and $|\eta| < 0.83$ (the BMTF region).

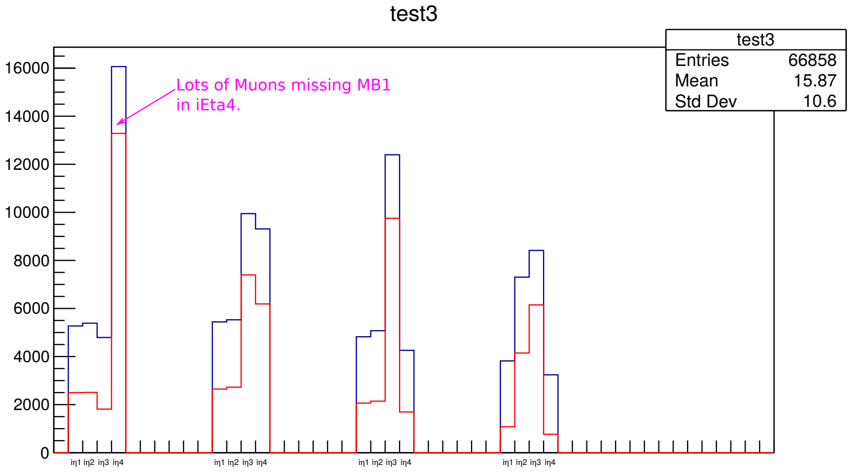
Next slide:

- Plot of DT stations associated (with TPs within $\Delta\phi < 0.1$) with reco-muons.
- For example, the entry in bin labelled "MB 123" is the number of muons that have associated TPs in stations 1, 2, and 3.
- The 4 blocks of entries are for $i\eta 1$ to $i\eta 4$ (left to right).
- Red: LQ+HQ. Blue: HQ


test2
test2
Entries 702
Mean 45
Std Dev 27
10000
8000
6000
4000
2000
0
Muons with ONLY MB1

Next slide:

- Plot of $i\eta$ distribution of muons missing (without TPs within $\Delta\phi < 0.1$) stations 1 to 4 (the 4 block of entries, left to right).
- For example, the entry in the bin labelled $i\eta3$ of the 3rd block is the number of muons missing station 3 in the region $i\eta3$.
- Red: Without both LQ and HQ. Blue: Without HQ only
- The plot essentially shows the $i\eta$ distribution of the wh0-wh1 gaps (and inefficient regions) of the muon stations.


test3
test3
Entries 66858
Mean 15.87
Std Dev 10.6
Lots of Muons missing MB1
in iEta4.
16000
14000
12000
10000
8000
6000
4000
2000
0
iη1 iη2 iη3 iη4
iη1 iη2 iη3 iη4
iη1 iη2 iη3 iη4
iη1 iη2 iη3 iη4

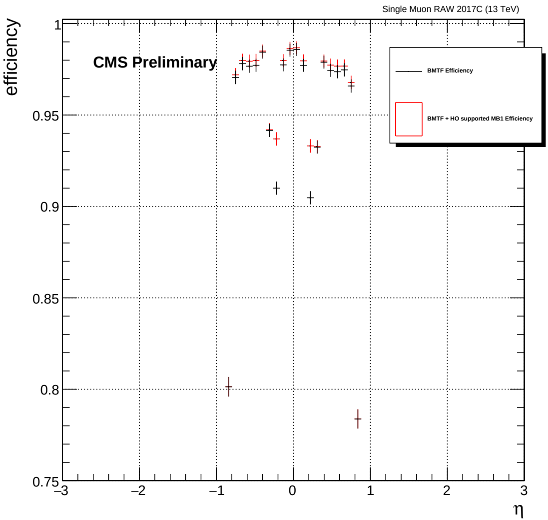
- We see that the wh0-wh1 gaps of the DT lie mostly in $i\eta 3$ and 4.
- **For the MB1+HO algorithm to work, one needs HQ MB1TPs to exist in the first place.**
- Since those are lacking in $i\eta 4$, the algorithm will be useful only in $i\eta 3$.
- So MB1+HO ($i\eta 3$) will support the wh0-wh1 gaps in MB2/3/4.

MB1+HO: Algorithm

1. Take the HQ MB1TPs.
2. Look for the ones that are **unused** by the BMTF. Call these unused TPs isoMB1 ("iso" implies isolated).
   Technical detail[1]: If there is a BMTF track with TA (Track Address) 1 or 2 (i.e. the track has used MB1) in the same sector as the TP, the TP is **used**. **The matching is uniquely performed.**
3. For these isoMB1 TPs, look for an HOTP (**in SOI**) in the same wheel such that $\Delta i\phi \leq 1$ (1 HO tile window). Call these isoMB1+HO. **The matching is uniquely performed.**
4. **For rate estimate:** count the number of isoMB1+HO per event. More details later.
5. **For efficiency estimate:** impose the additional condition that isoMB1+HO must be matched to a reco-muon with $\Delta R < 0.4$. More details later.

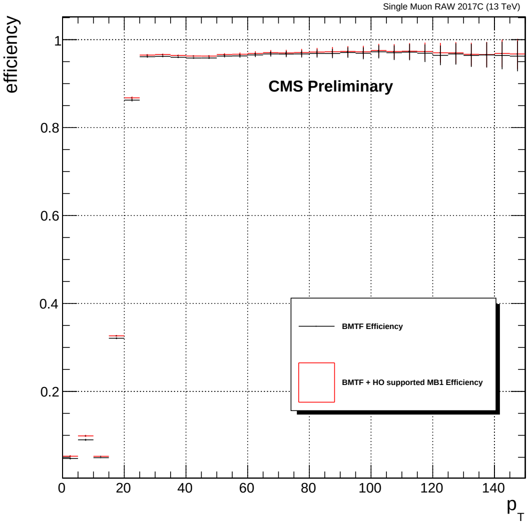
[1] Courtesy of Georgios

- **Sample:** `/SingleMuon/Run2017C-ZMu-PromptReco-v3/RAW-RECO`
- Match BMTF tracks and isoMB+HO to reco-muons (tight) with $\Delta R < 0.4$. **The matching is unique.** So, a single muon can be matched to either a BMTF track OR an isoMB1+HO, not both.
- p_T, η cuts followed from https://twiki.cern.ch/twiki/bin/view/CMSPublic/Level1TriggerMuonPerformance2017andLegacy.
- For ϵ vs. p_T: $p_T^{BMTF} > 25$, $|\eta| < 0.83$.
- For ϵ vs. η: $p_T^{BMTF} > 25$, $p_T^{\mu} > 30$, $|\eta| < 0.83$.

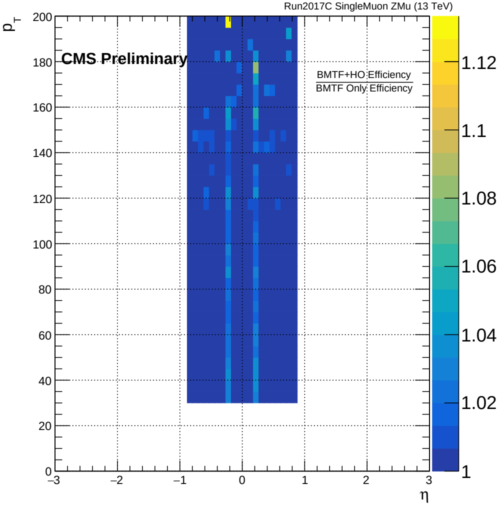


Single Muon RAW 2017C (13 TeV)
CMS Preliminary
efficiency
η
BMTF Efficiency
BMTF + HO supported MB1 Efficiency
1
0.95
0.9
0.85
0.8
0.75
−3
−2
−1
0
1
2
3

MB1+HO: Efficiency [3]



MB1+HO: Efficiency [4]



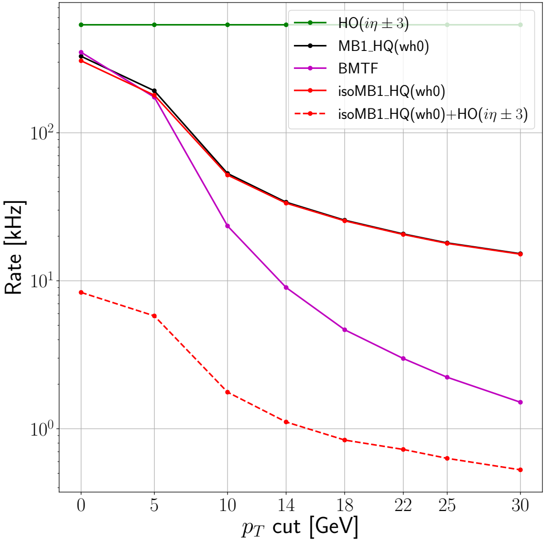
- **Sample:** `/ZeroBias9/Run2017B-v1/RAW`
- The rate (R) of an object is calculated as the following.

$$R = \frac{N_{obj}}{N_{ev}} \times 40 \text{ MHz}$$

This is the "worst case scenario", as the realistic rate will include the bunch filling fraction (f).

$$f = \frac{N_{bunch}^{filled}}{N_{bunch}^{all}}$$

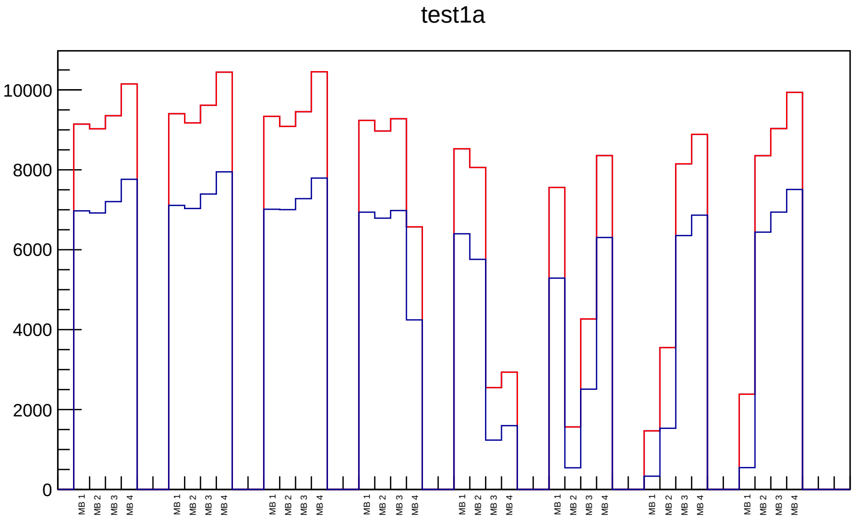
- **For rates involving DTTPs, there is an extra factor of 1/3 because the DT records 3 time samples and no selection on that has been made.**
- The plot on the next slide shows the rate as a function of p_T threshold. The p_T of the MB1TP is read from LUTs.


HO($i\eta \pm 3$)
MB1_HQ(wh0)
BMTF
isoMB1_HQ(wh0)
isoMB1_HQ(wh0)+HO($i\eta \pm 3$)
Rate [kHz]
10^2
10^1
10^0
0
5
10
14
18
22
25
30
p_T cut [GeV]

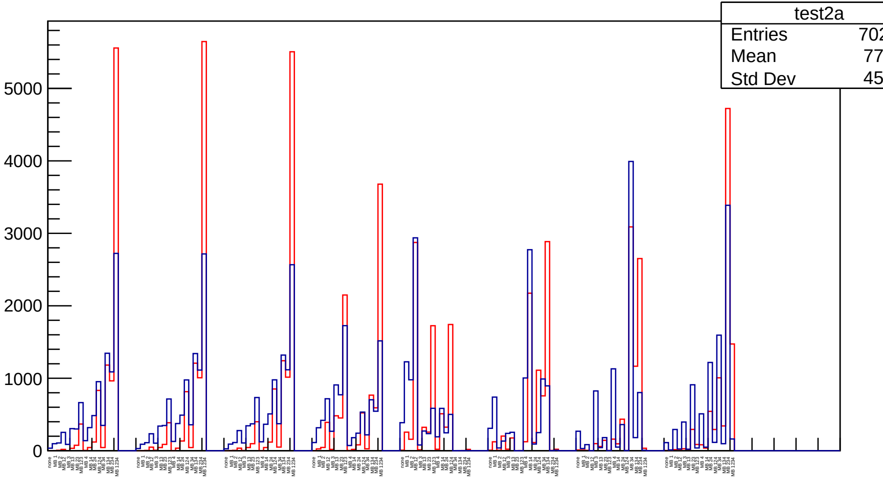
Summary

- At a p_T threshold of 22 GeV we are looking at $\sim 3\%$ efficiency gain in $i\eta 3$ at the cost of $\sim 25\%$ increase in BMTF rate.
- Will be looking into rate vs. pileup.

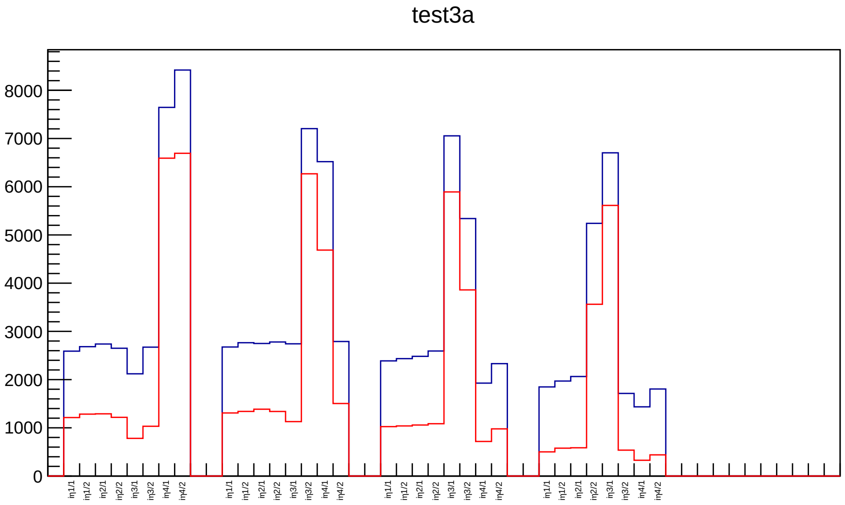
Backup


test1a
10000
8000
6000
4000
2000
0
MB 1
MB 2
MB 3
MB 4

test2a



test2a
Entries 702
Mean 77
Std Dev 45
5000
4000
3000
2000
1000
0


test3a
8000
7000
6000
5000
4000
3000
2000
1000
0
iη1/1
iη1/2
iη2/1
iη2/2
iη3/1
iη3/2
iη4/1
iη4/2