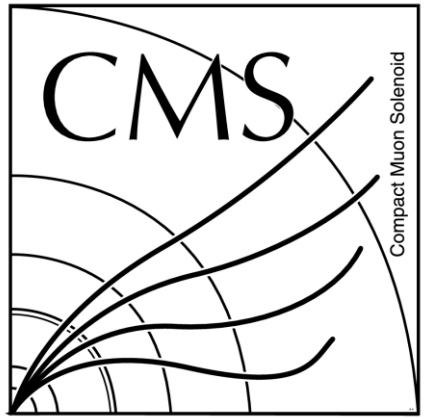
EMTF Studies on Reconstructed Muons

EMTF Working Meeting
March 2018

Wei Shi on behalf of the
EMTF working group

RICE

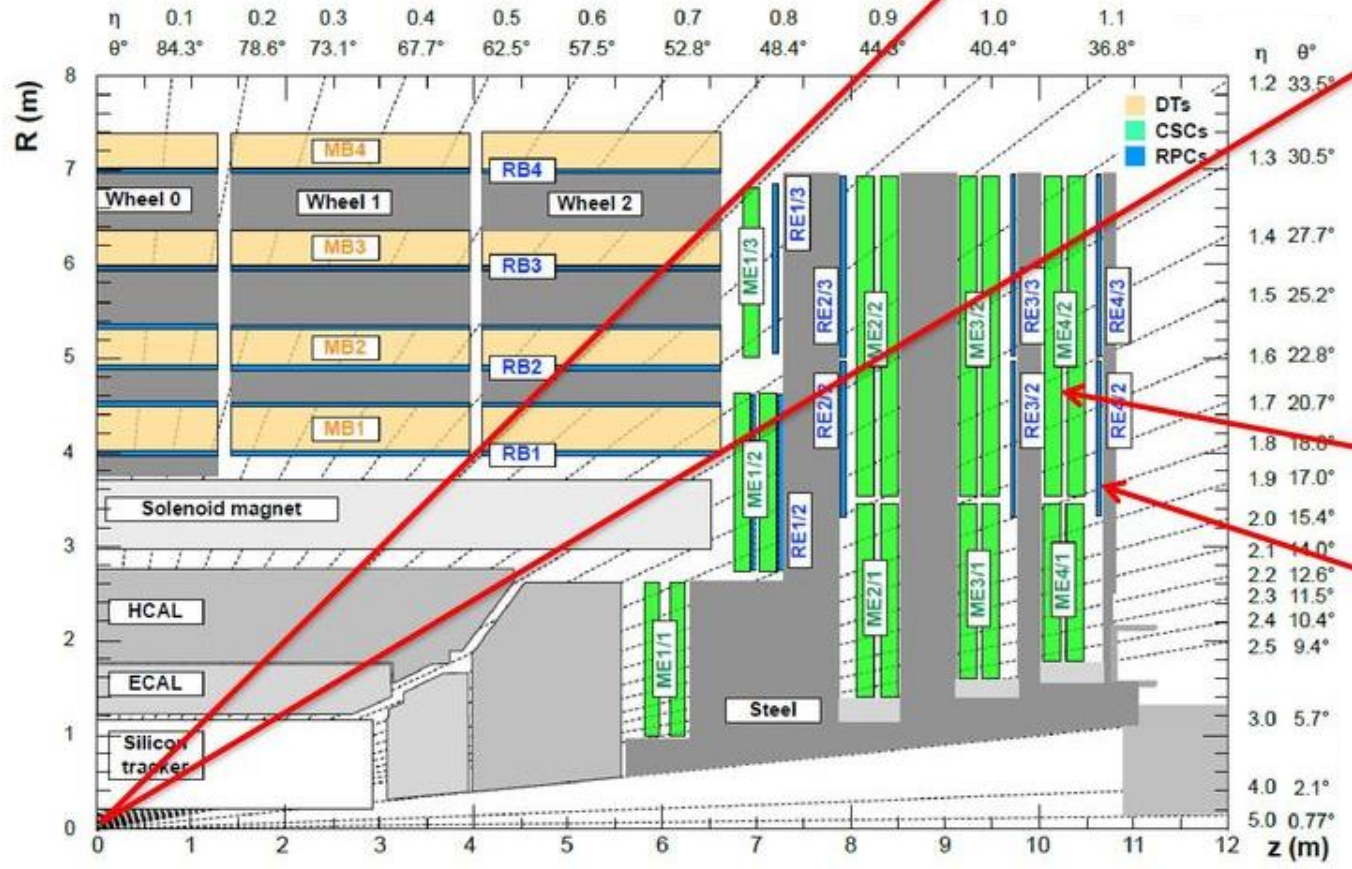
UF | UNIVERSITY of FLORIDA



Geometry

Barrel Muon Track Finder (BMTF)

Overlap Muon Track Finder (OMTF)



Endcap Muon Track Finder (EMTF)

Cathode Strip Chambers (CSC)

Resistive Plate Chambers (RPC)

EMTF Track-building

- At most 4 stations (CSC or RPC)
  - Local Charged Tracks (LCTs) or RPC hits correlated in theta (±2°) and phi (±8° in station 1, ±4° in stations 2 - 4)
  - Tracks built from LCTs and RPC hits from 3 consecutive bunch crossing (BX)
    - Will be reduced to 2 BX in 2018
    - LCT mis-timing rate < 1% (conservative) per LCT (the actual collision BX where the LCT is from)
  - Track BX assigned using the 2nd-earliest LCT or RPC hit in the track
    - For a 3 or 4-station track, the track BX will always be fine
    - For a 2-station track, if one LCT has mistiming(<1%), then it's possible track BX is not right
  - pT assignment mostly based on dPhis between stations

- Magnetic field strongest between stations 1 and 2, very little bending after that - so station 1 is important

Motivations

- Study on EMTF rate and efficiency by track modes/quality
  - Tracks/modes contribute to the most efficiency; pT range
  - Tracks/modes contribute to the most rate; pT range

- Implications
  - Modify the current muon quality assignment for EMTF?
  - How to improve the current EMTF track-building?
  - What tracks to use in EMTF pT training in 2018?

- Interested parameter ranges
  - 0 < pT < 30 GeV (L1 muon trigger pT)
  - 1.25 < Eta < 2.4 (Endcap)

Matching

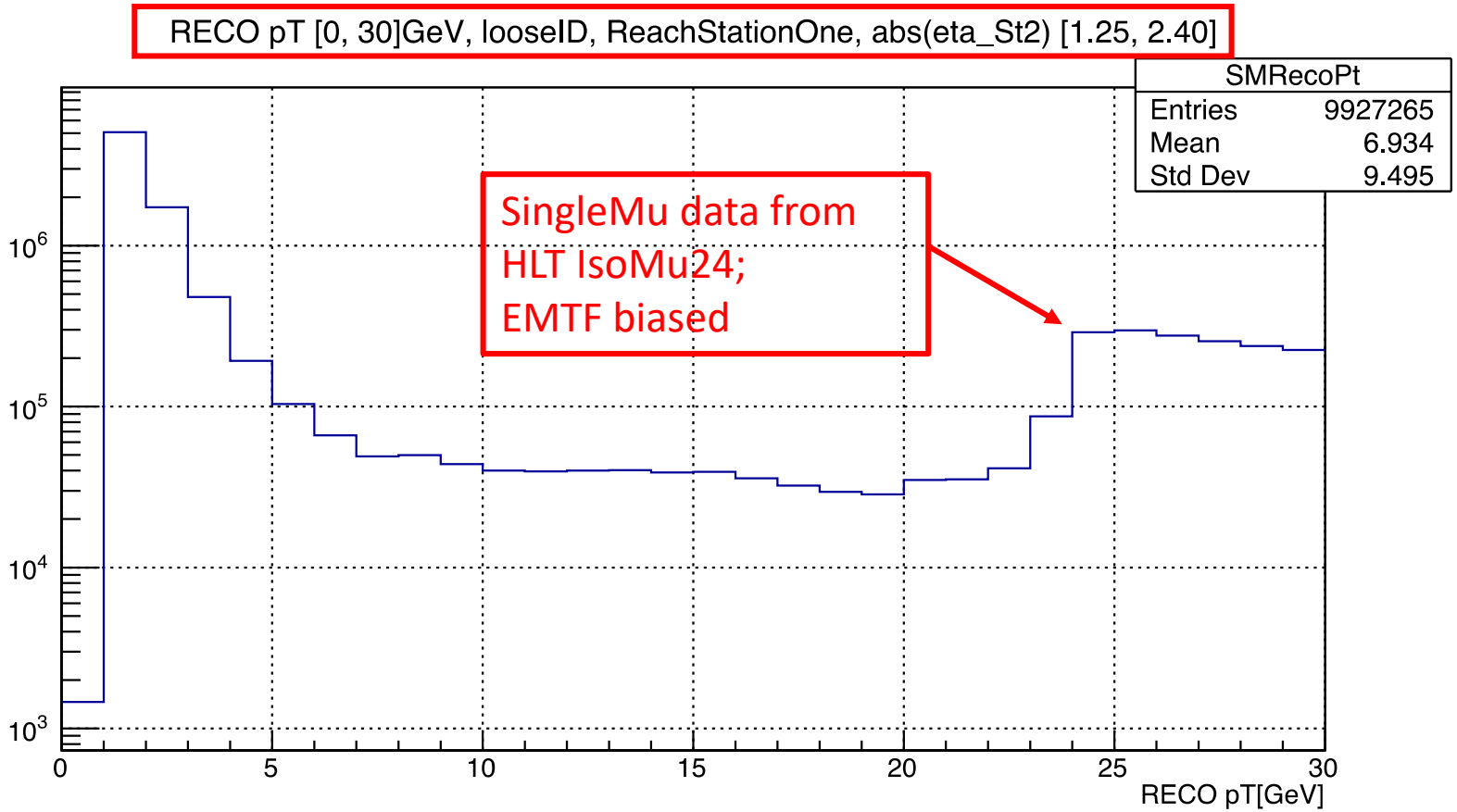
- RECO muon
  - ID [1] : Normal (loose), Soft
  - coordinates extrapolated to station 1 or 2
- dR based: dR < 0.5
- Unique: match is reciprocal

- dBX: LCTs max BX – min BX
  - dBX = 0 means all LCTs from a track come from the same BX
- Plateau: require EMTF track pT > RECO mu pT *(7/8)

- 2017 data
  - SingleMu: 14,750,159 events (efficiency)
  - ZeroBias: 6,247,725 events (rate)

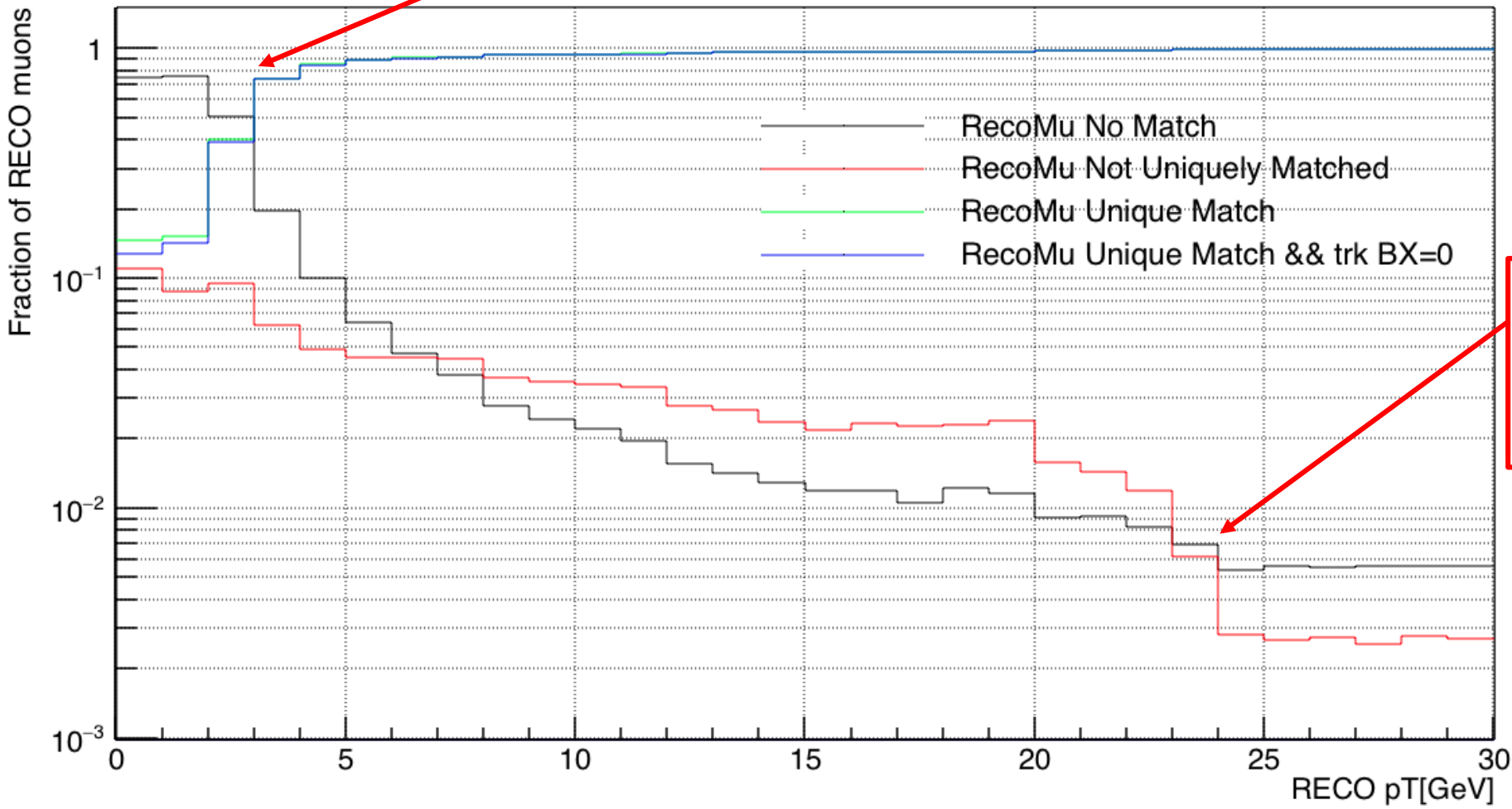
[1] https://twiki.cern.ch/twiki/bin/viewauth/CMS/SWGuideMuonIdRun2#Muon_Identification

RECO Muon pT


RECO pT [0, 30]GeV, looseID, ReachStationOne, abs(eta_St2) [1.25, 2.40]
SMRecoPt
Entries 9927265
Mean 6.934
Std Dev 9.495
SingleMu data from
HLT IsoMu24;
EMTF biased
10^6
10^5
10^4
10^3
0
5
10
15
20
25
30
RECO pT[GeV]

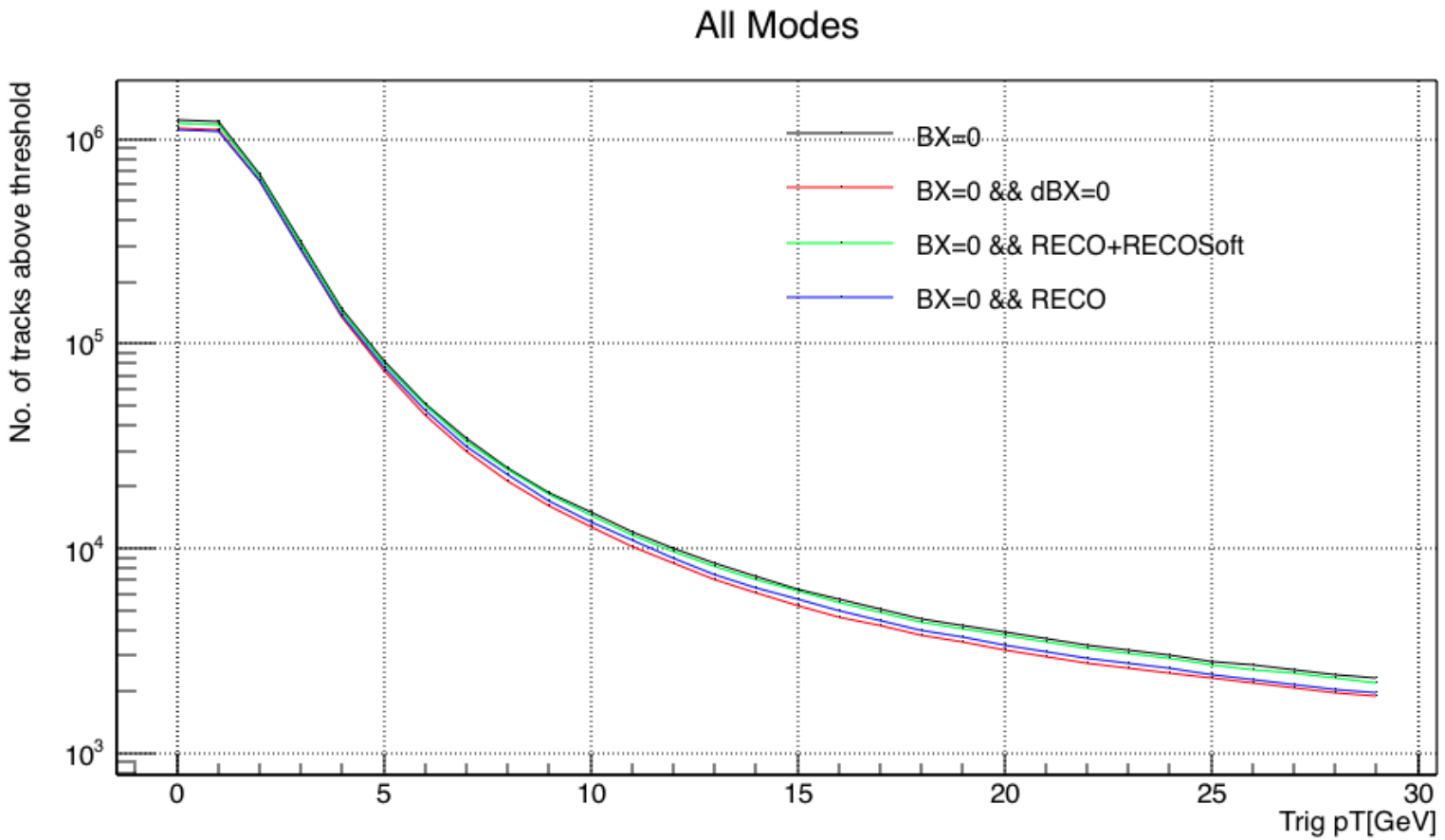
Match Scenarios

EMTF has good track-building efficiency & timing down to 3 GeV



IsoMu24 Biased: Find match because they are fired by EMTF

EMTF Tracks

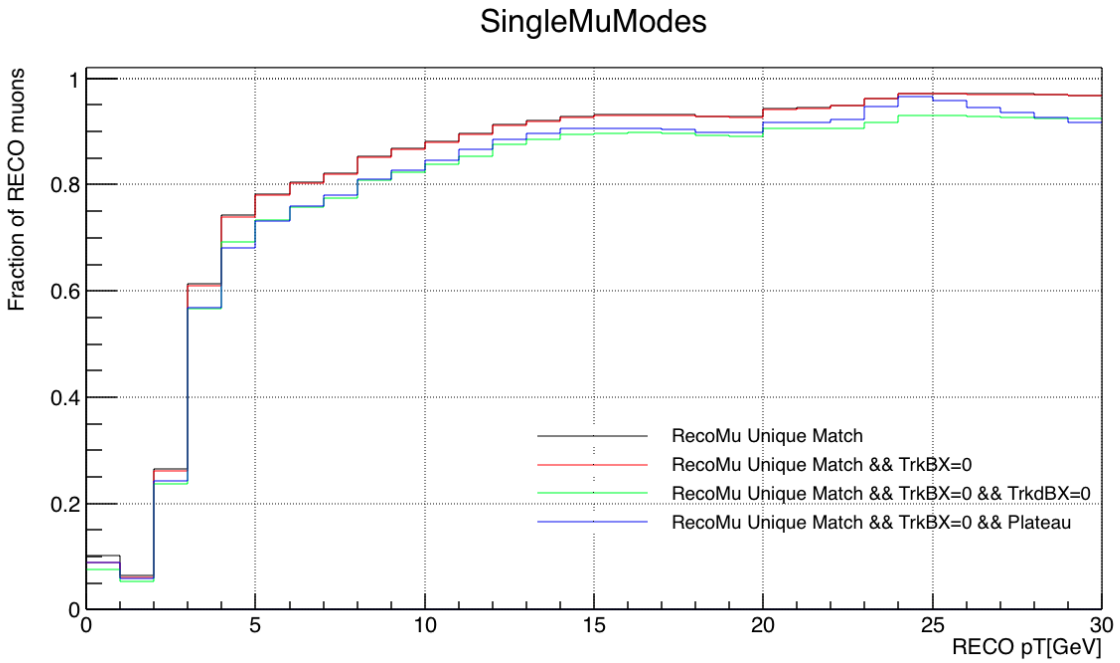

All Modes
No. of tracks above threshold
10^6
10^5
10^4
10^3
0
5
10
15
20
25
30
Trig pT[GeV]
BX=0
BX=0 && dBX=0
BX=0 && RECO+RECOSoft
BX=0 && RECO

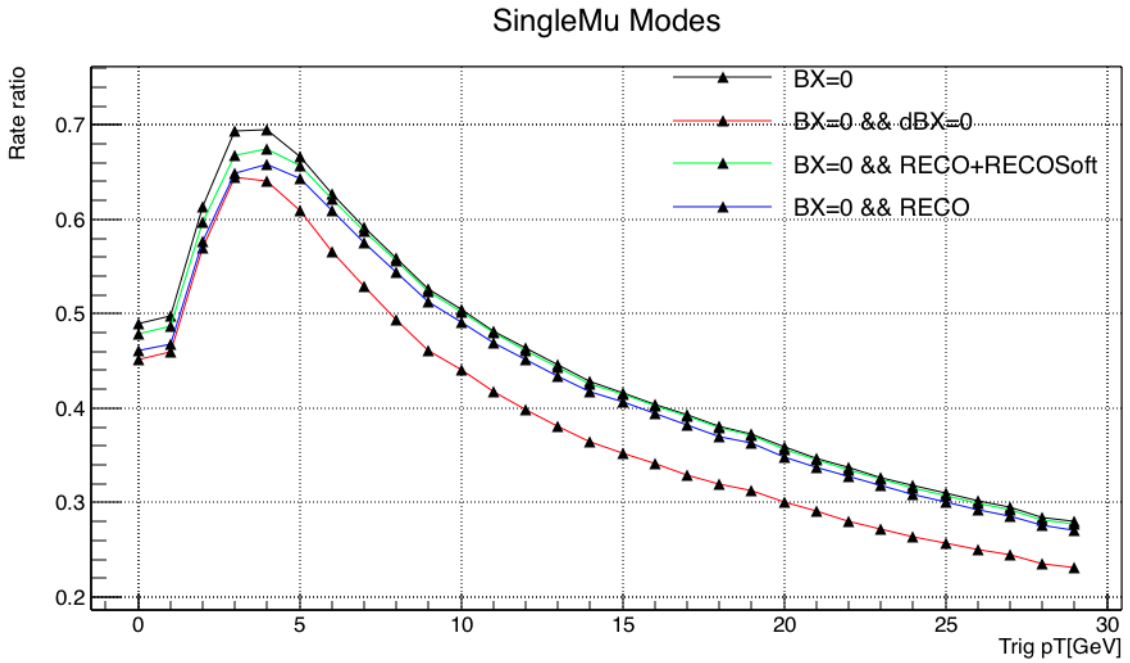
Muon Quality from uGMT

- SingleMu Quality (Q>=12)
  - EMTF mode 15, 14, 13, 11
- DoubleMu Quality (Q>=8)
  - EMTF mode 12, 10, 7
- MuOpen Quality (Q>=4)
  - EMTF mode 9, 6, 5, 3

Mode #	Definition	Stations
15	1+2+4+8	1,2,3,4
14	2+4+8	1,2,3
13	1+4+8	1,2,4
12	4+8	1,2
11	1+2+8	1,3,4
10	2+8	1,3
9	1+8	1,4
7	1+2+4	2,3,4
6	2+4	2,3
5	1+4	2,4
3	1+2	3,4

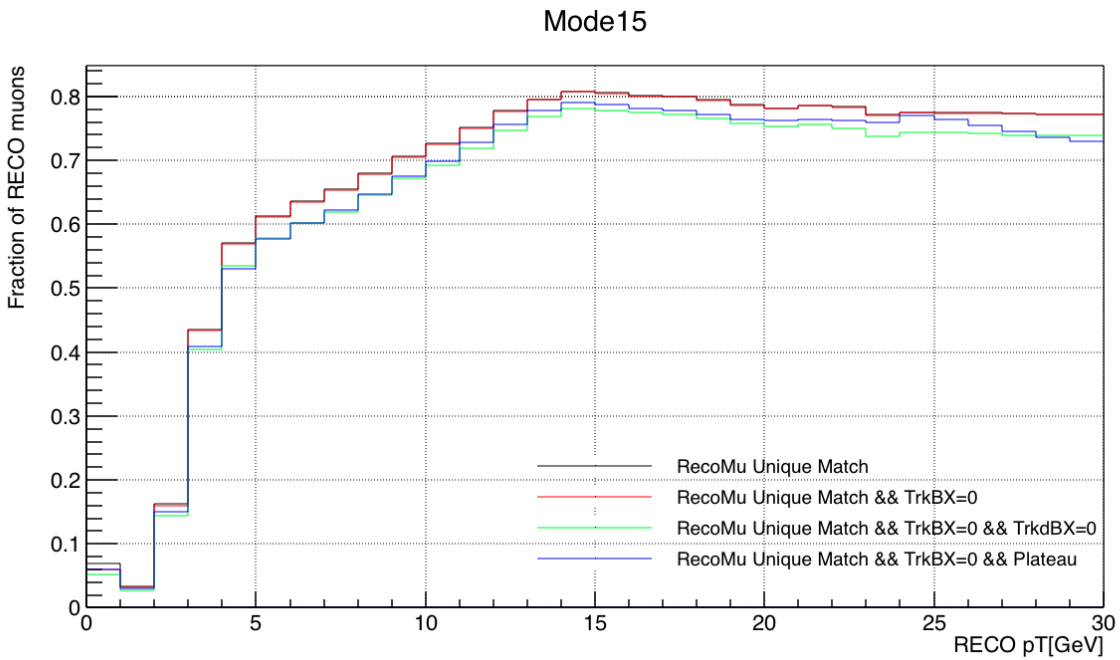
SingleMu Modes

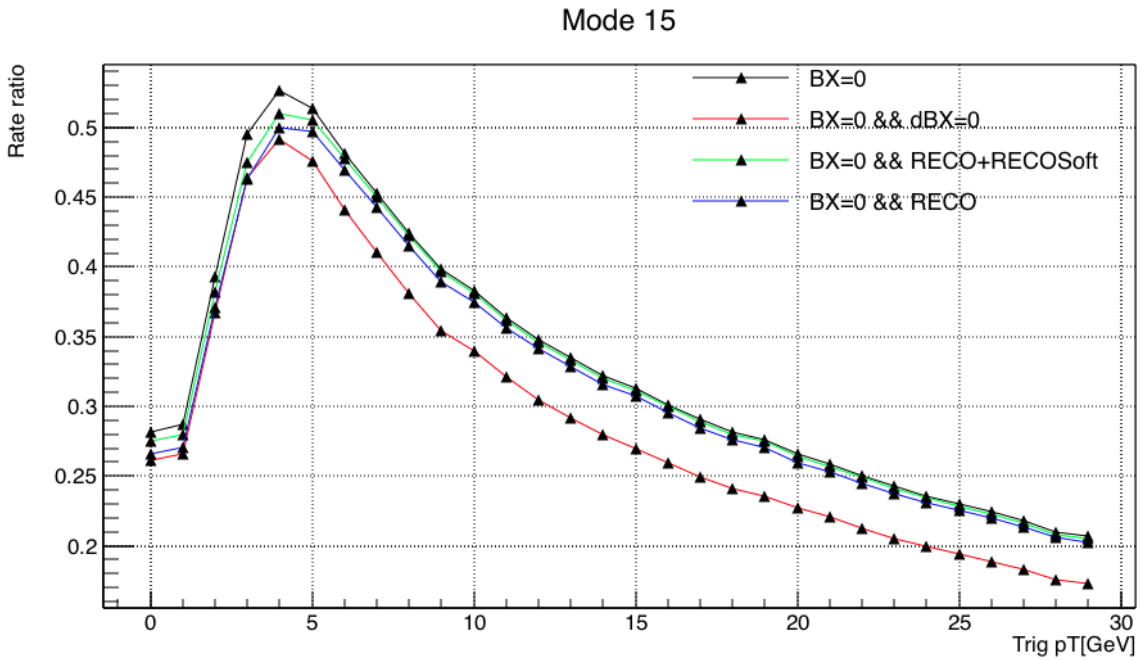




- Left: Fraction of RECO muons from SingleMu data; Right: ratio = count/total count (BX=0) from Zerobias data
- pT>5 GeV: plateau efficiency is 80%-95%
- pT>5 GeV: contribution to rate decreases from 66% to 22% as pT increases (exactly what we want: high eff, low rate)

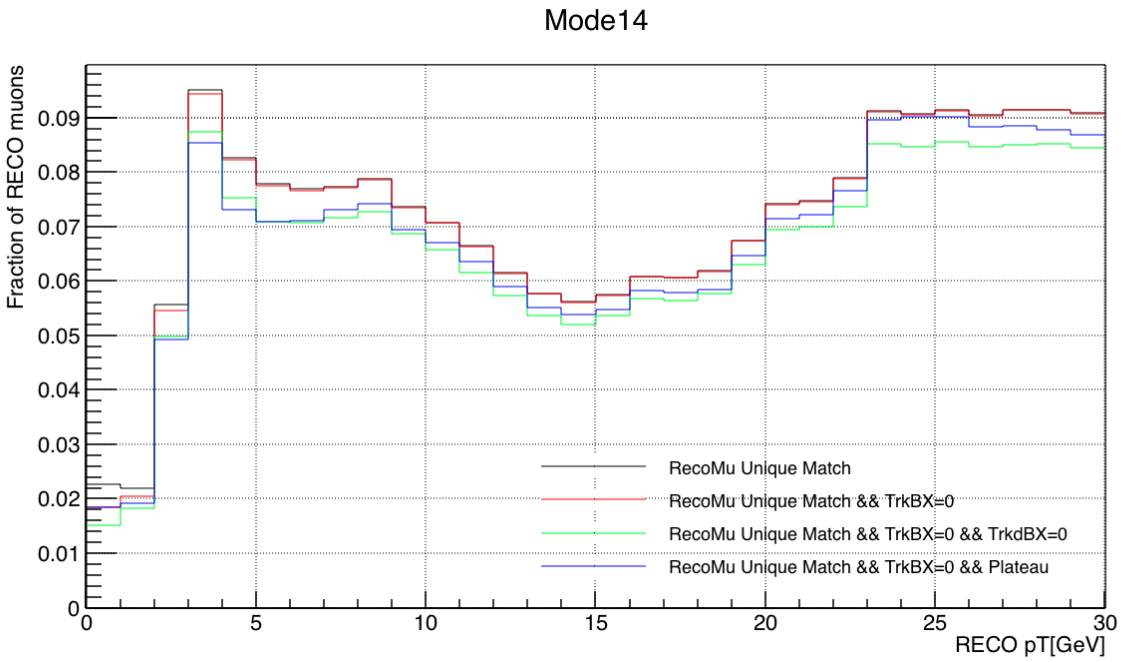
Mode 15 (station 1-2-3-4)

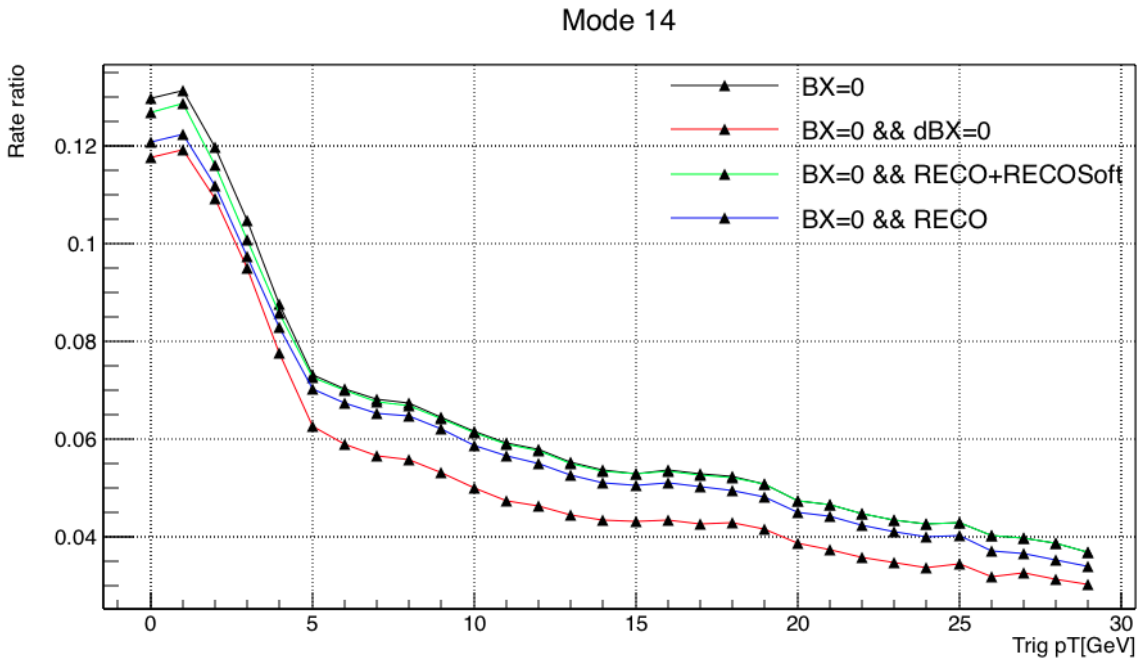




- Account for most efficiency in EMTF tracks
- pT<5 GeV: contribution to rate is reasonable, linear to efficiency;
- pT>15 GeV: plateau efficiency is high (75%~80%) but rate contribution drops below 30%

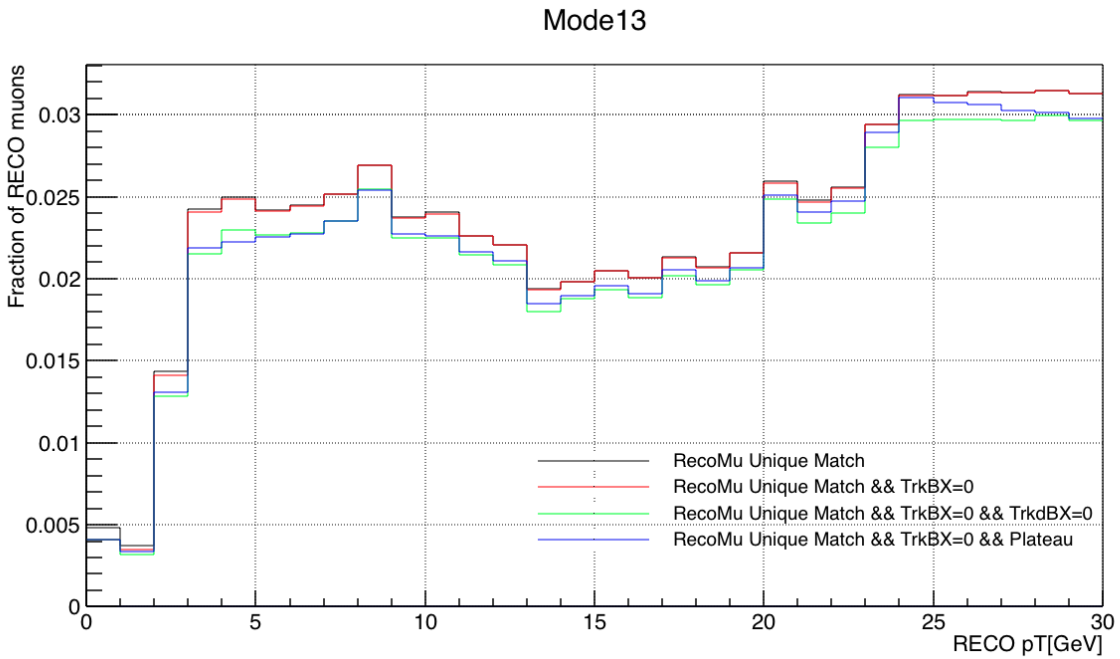
Mode 14 (station 1-2-3)

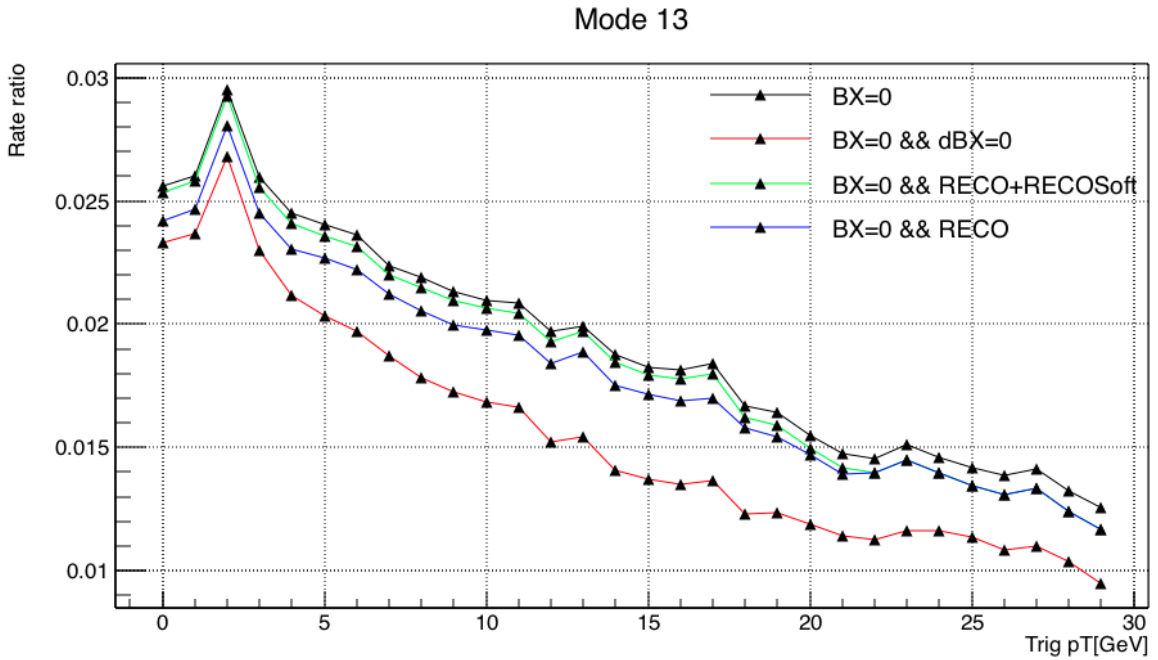




- pT>10 GeV: efficiency is already 10 times smaller than mode 15
- Contribution to rate is reasonable, mostly below 12% with a plateau efficiency 5%-9%

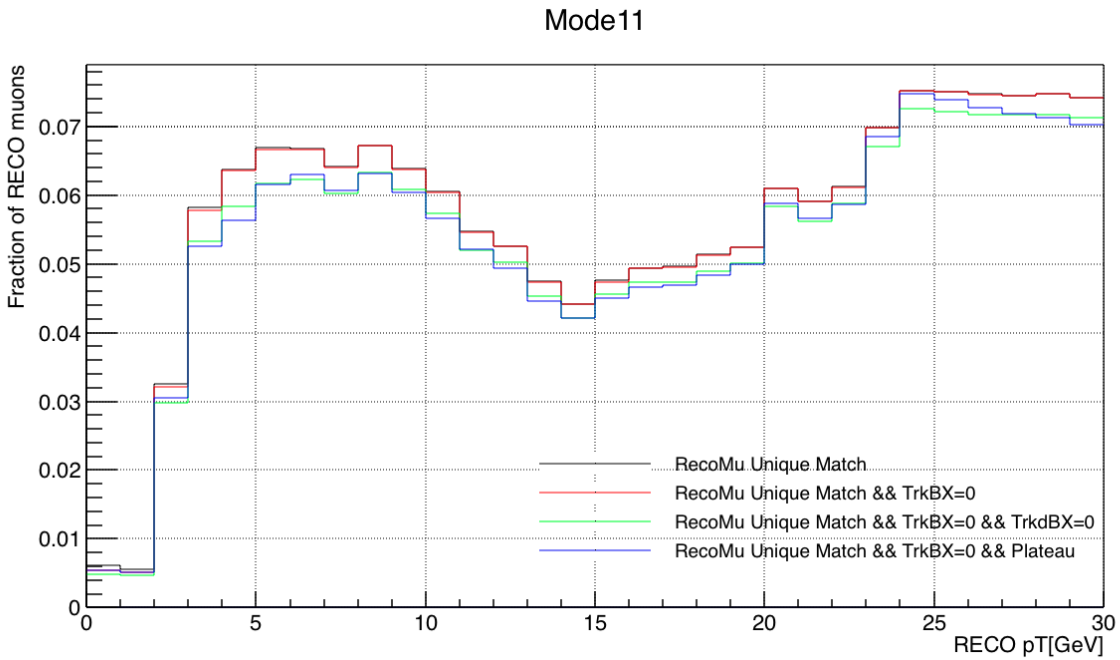
Mode 13 (station 1-2-4)

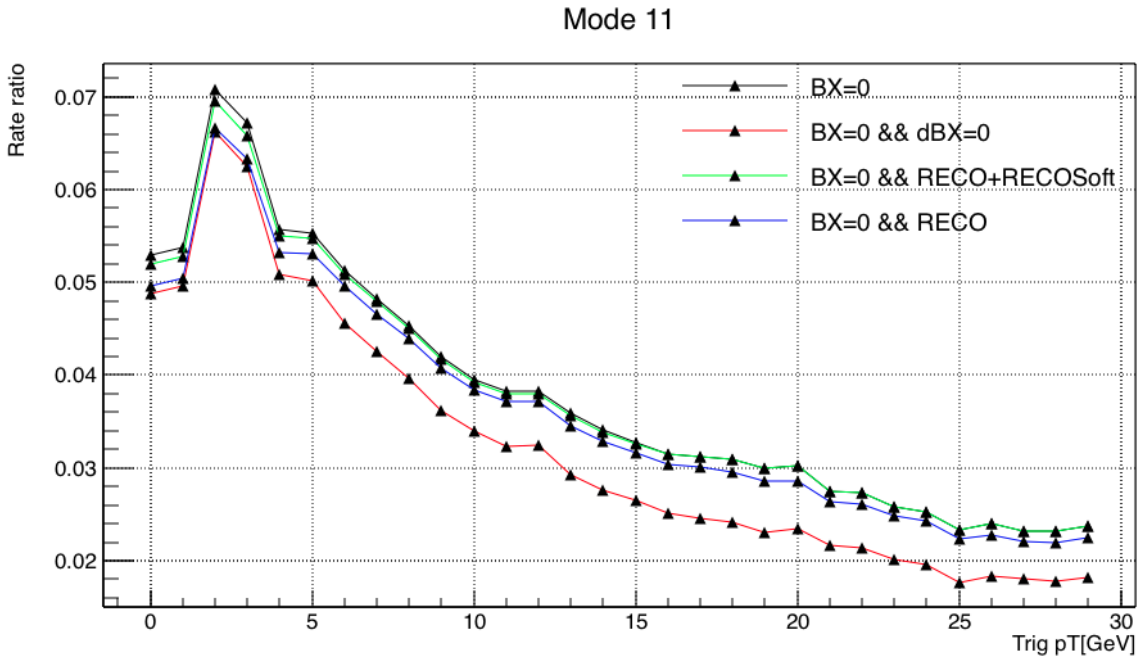




- Efficiency is even lower than mode 14 (station 1-2-3)
- Contribution to rate is reasonable, mostly below 3% with a plateau efficiency 2%-3%

Mode 11 (station 1-3-4)





- Efficiency is between mode 13 (station 1-2-4) and mode 14 (station 1-2-3)
- Contribution to rate is reasonable, mostly below 7% with a plateau efficiency 5%-7%

Muon Quality from uGMT

- SingleMu Quality (Q>=12)
  - EMTF mode 15, 14, 13, 11
- DoubleMu Quality (Q>=8)
  - EMTF mode 12, 10, 7
- MuOpen Quality (Q>=4)
  - EMTF mode 9, 6, 5, 3

Mode #	Definition	Stations
15	1+2+4+8	1,2,3,4
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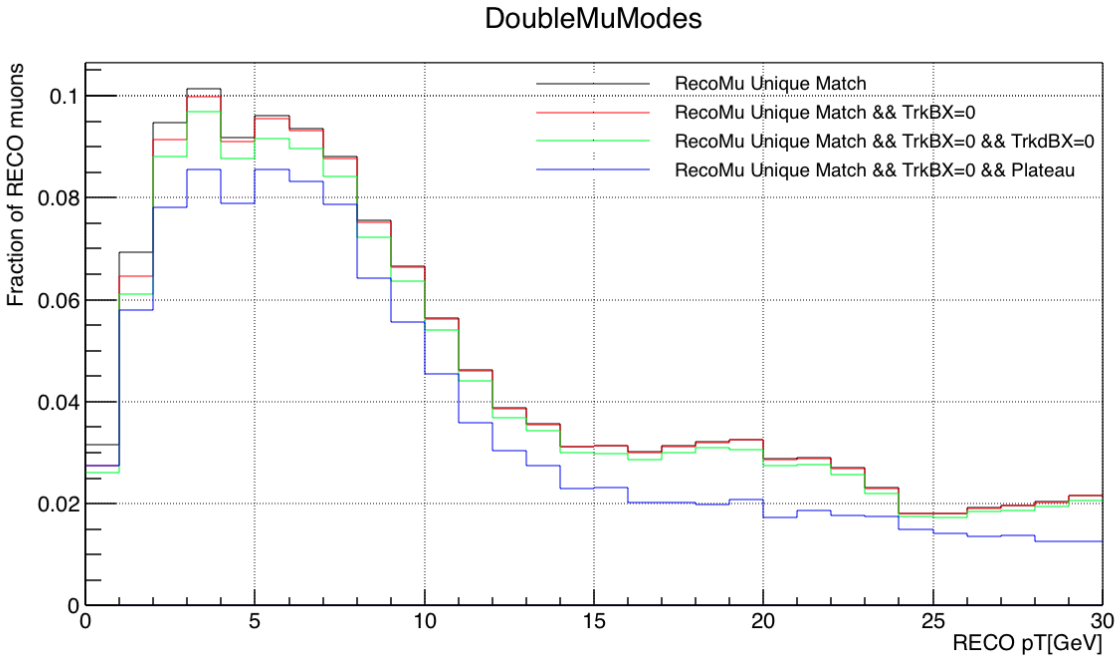
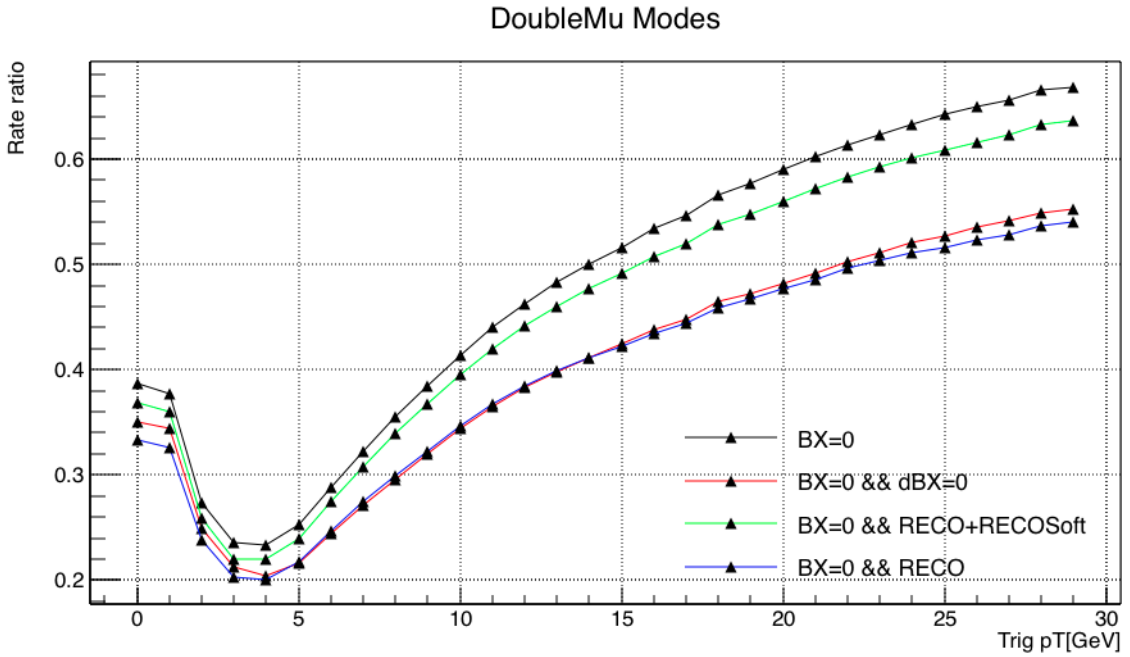
11	1+2+8	1,3,4
10	2+8	1,3
9	1+8	1,4
7	1+2+4	2,3,4
6	2+4	2,3
5	1+4	2,4
3	1+2	3,4

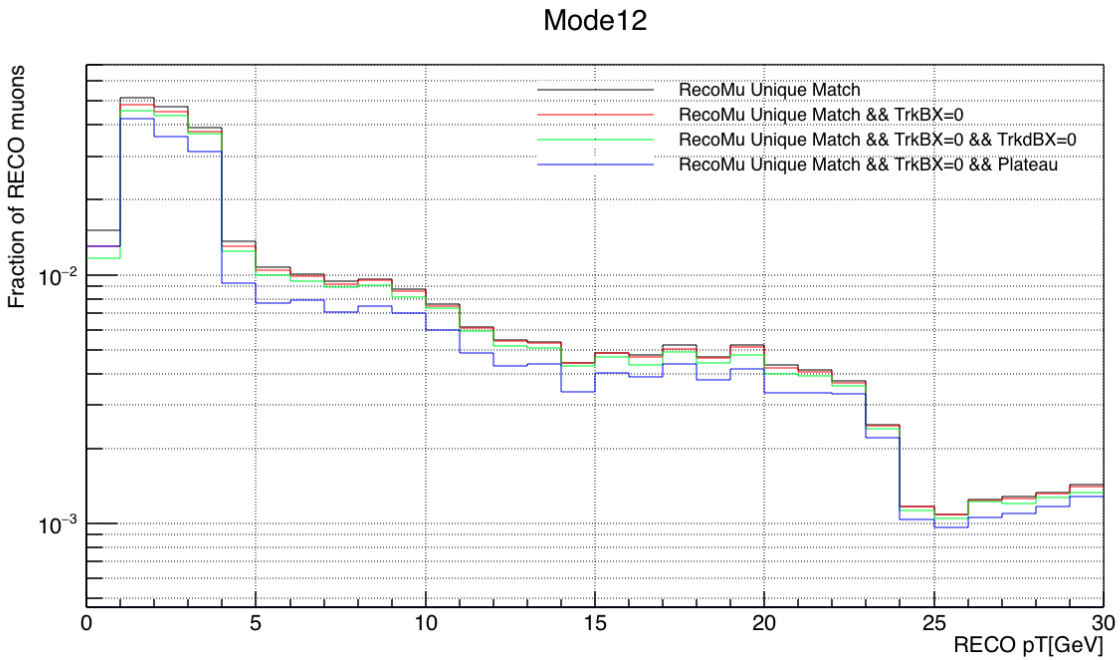
DoubleMu Modes

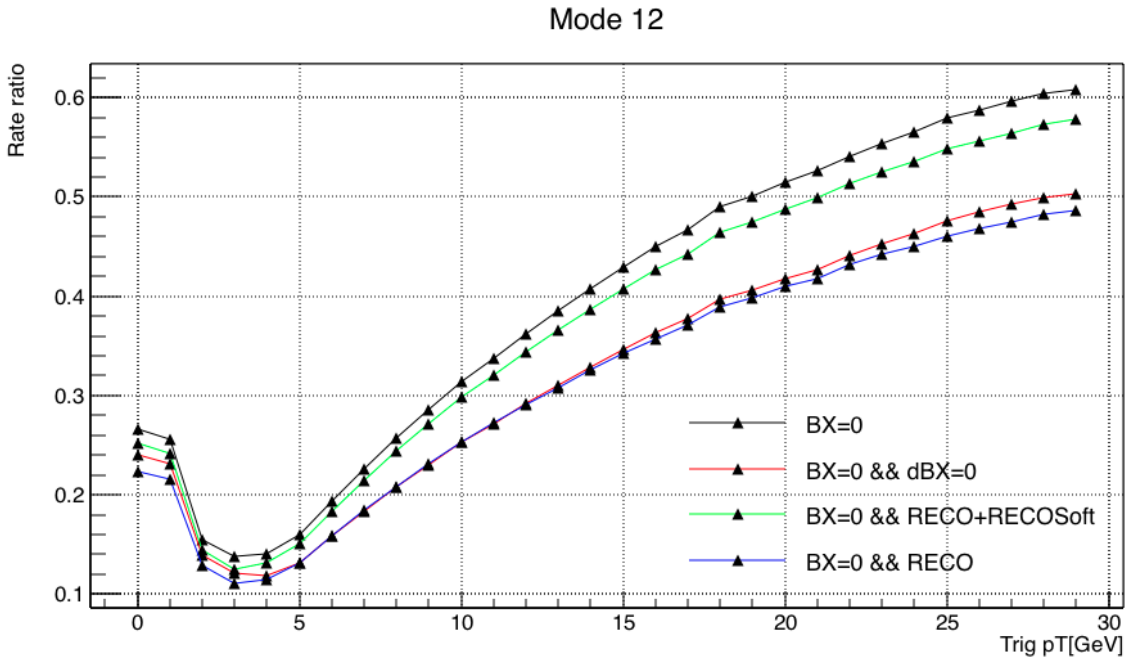




- Plateau efficiency is 10 times smaller than SingleMu modes (even lower in pT > 10GeV)
- pT>5 GeV: contribution to rate is surprisingly high, increase from 25% to 68% as pT increases
- Add “dBX=0” reduces ~10% rate (pT>15 GeV) without losing much efficiency

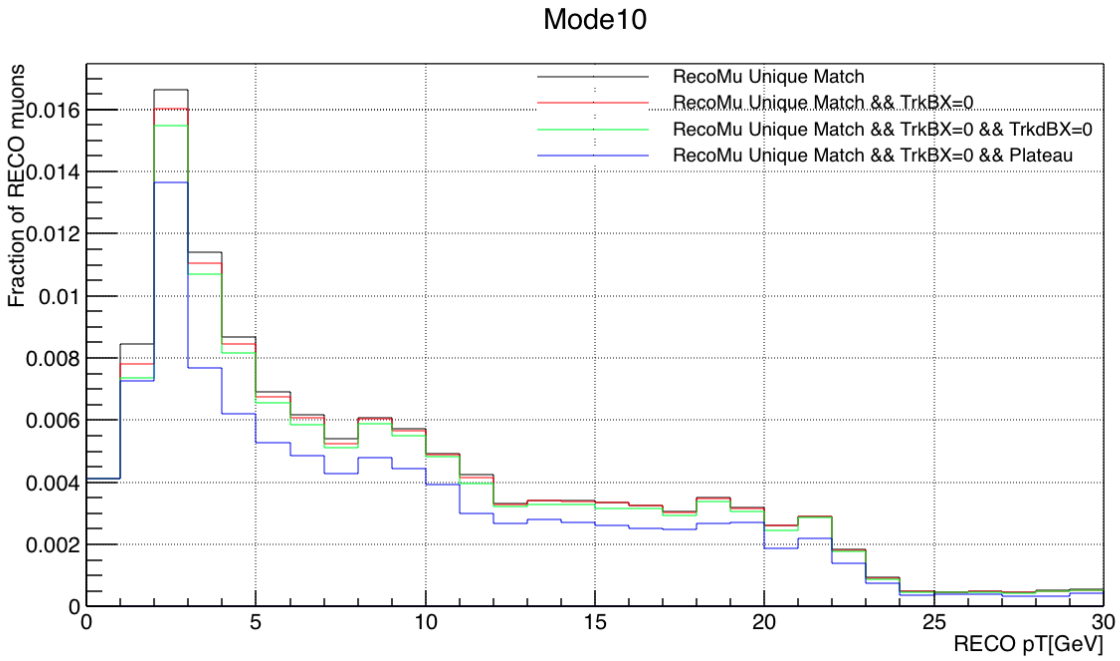
Mode 12 (station 1-2)

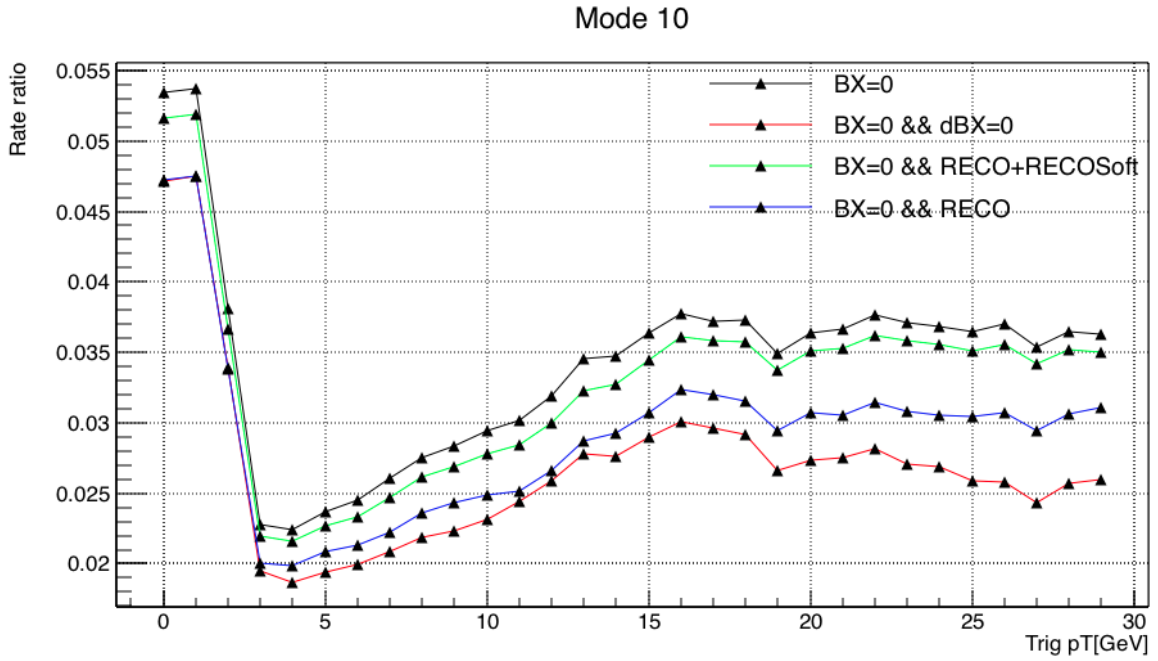




- pT>5 GeV: plateau efficiency is 100 times smaller than mode 15 (station 1-2-3-4)
- pT>5 GeV: contribution to rate is surprisingly high, increase from 15% to 60% as pT increases
- May need to put it in MuOpen quality

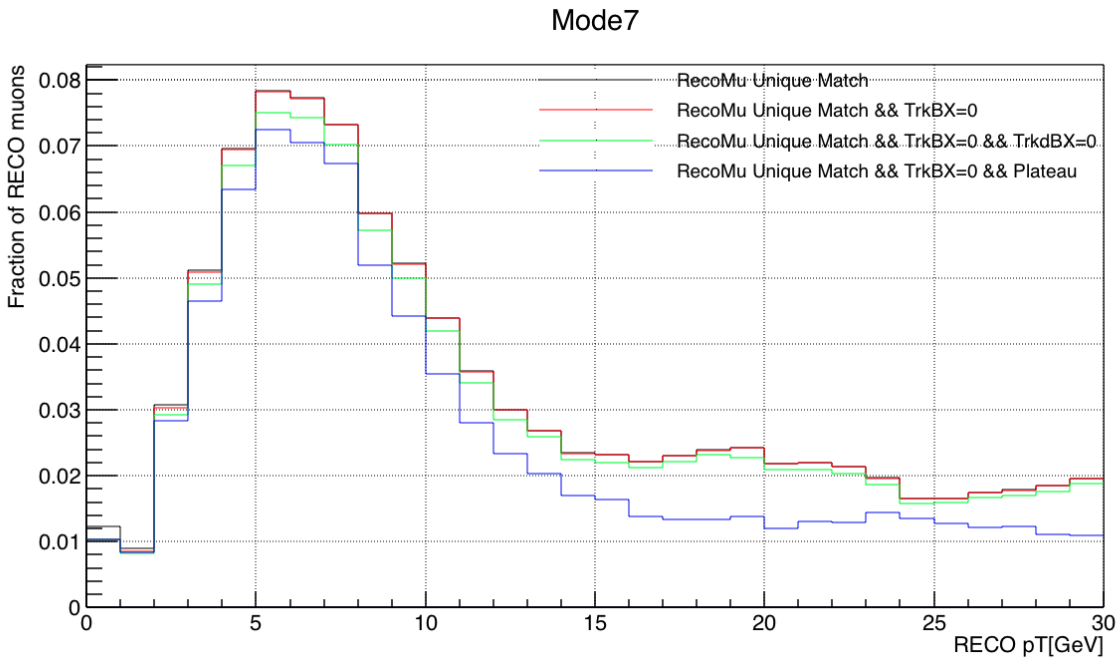
Mode 10 (station 1-3)

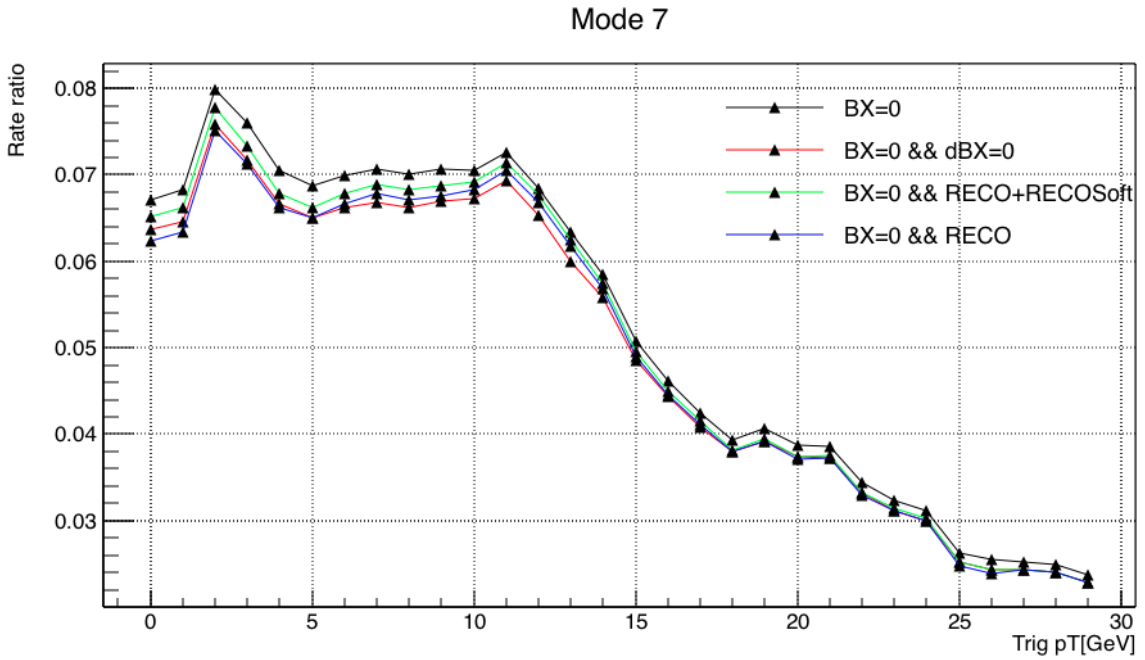




- pT>5 GeV: plateau efficiency is 100 times smaller than mode 15 (station 1-2-3-4)
- pT>5 GeV: overall contribution to rate is reasonable, but it increases from 2.4% to 3.7% as pT increases

Mode 7 (station 2-3-4)





- pT>5 GeV: plateau efficiency is 10 times smaller than mode 15 (station 1-2-3-4), even lower in pT > 15 GeV
- pT>5 GeV: contribution to rate is reasonable, 7%-2% as pT increases

Muon Quality from uGMT

- SingleMu Quality (Q>=12)
  - EMTF mode 15, 14, 13, 11
- DoubleMu Quality (Q>=8)
  - EMTF mode 12, 10, 7
- MuOpen Quality (Q>=4)
  - EMTF mode 9, 6, 5, 3

Mode #	Definition	Stations
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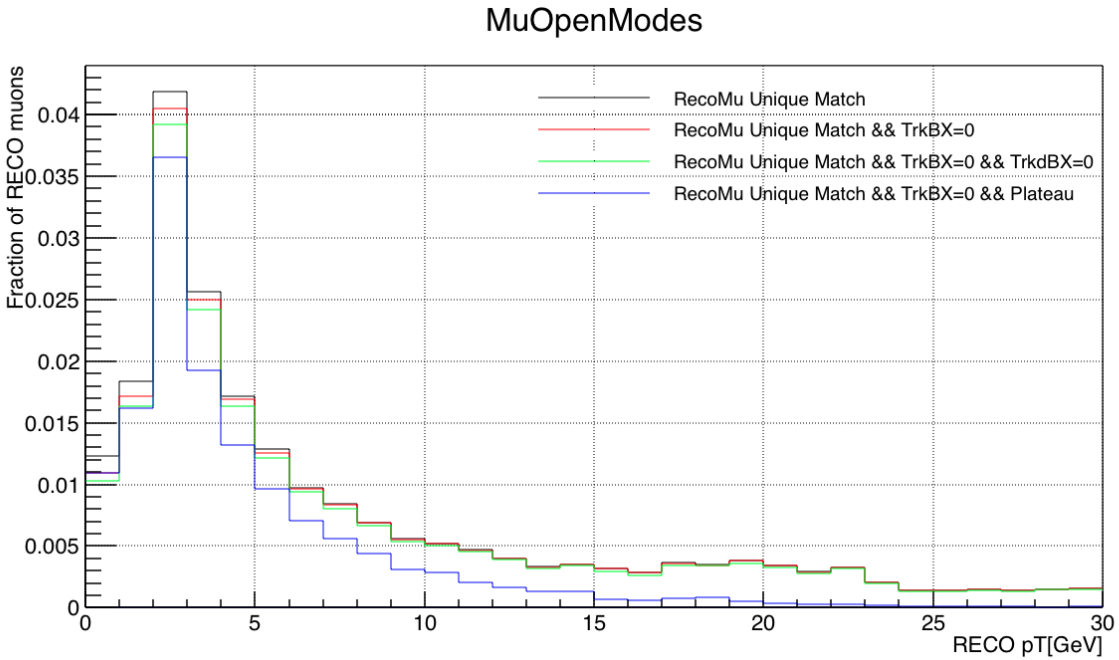
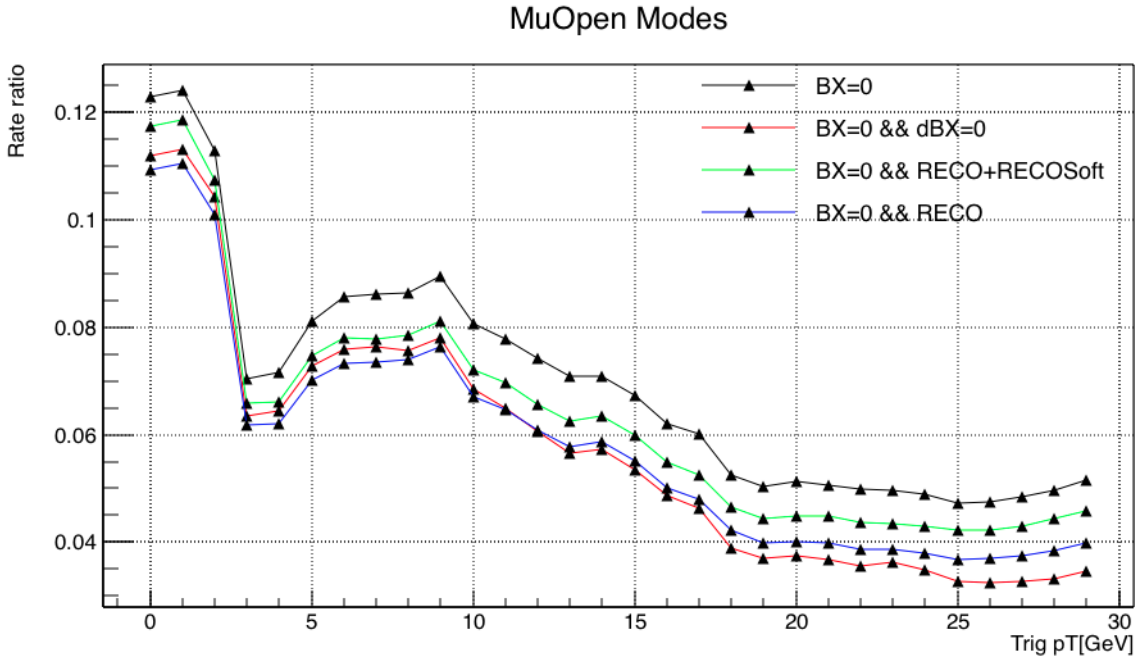
11	1+2+8	1,3,4
10	2+8	1,3
9	1+8	1,4
7	1+2+4	2,3,4
6	2+4	2,3
5	1+4	2,4
3	1+2	3,4

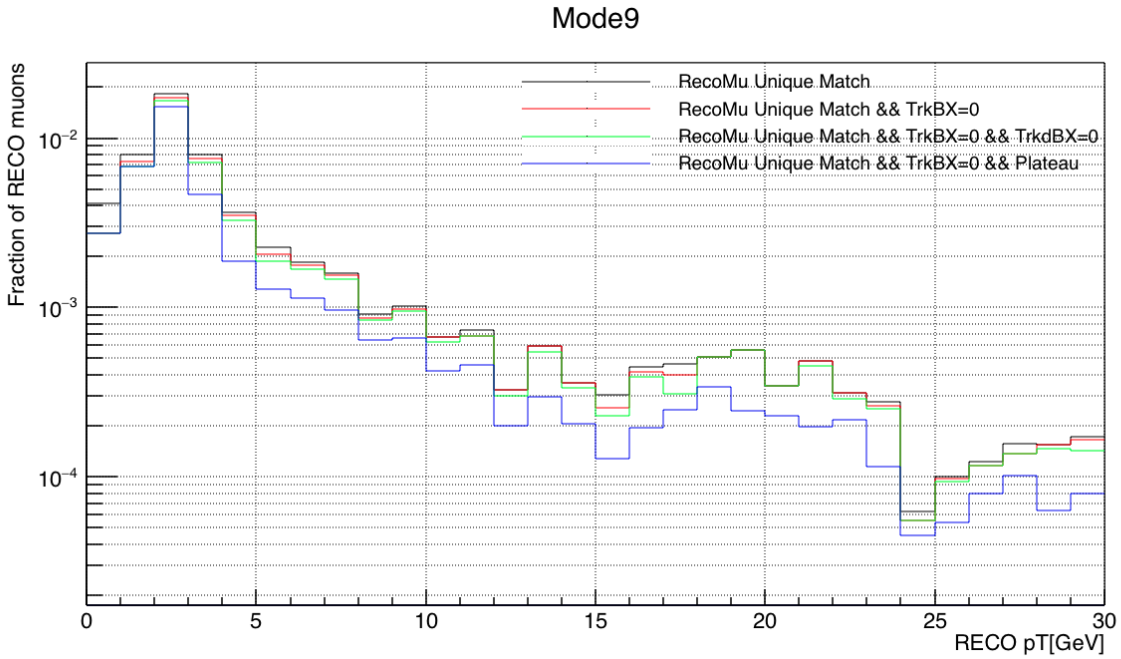
MuOpen Modes

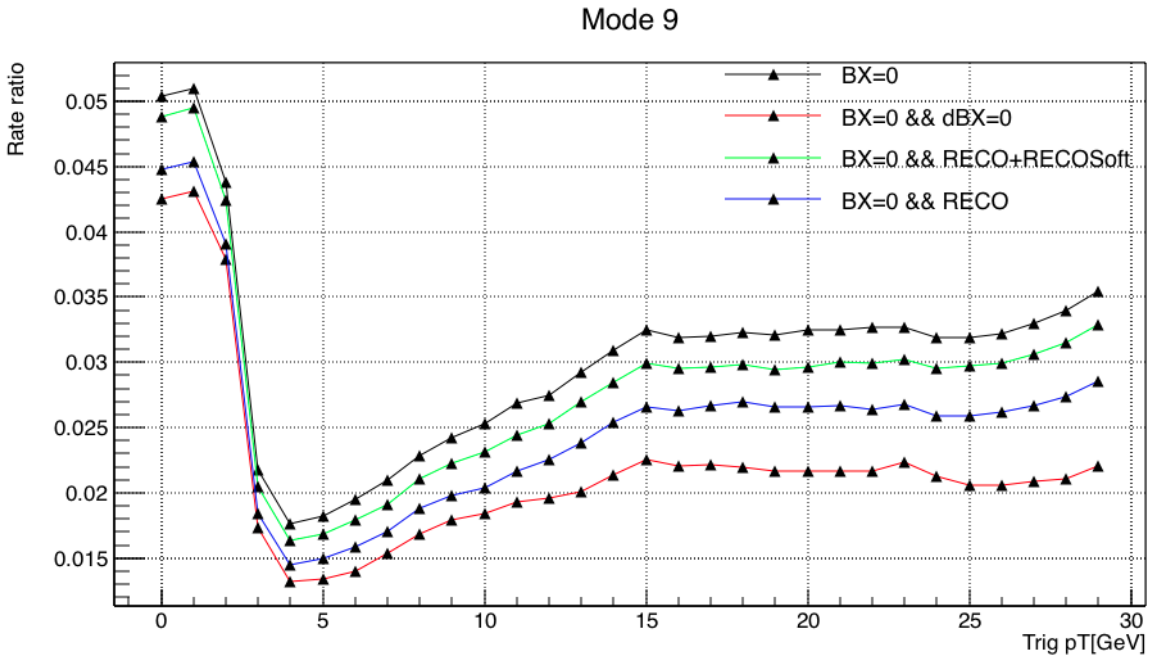




- pT>5 GeV: plateau efficiency is 1000 times smaller than SingleMu modes
- pT>5 GeV: contribution to rate looks reasonable, decreases from 9% to 5% as pT increases

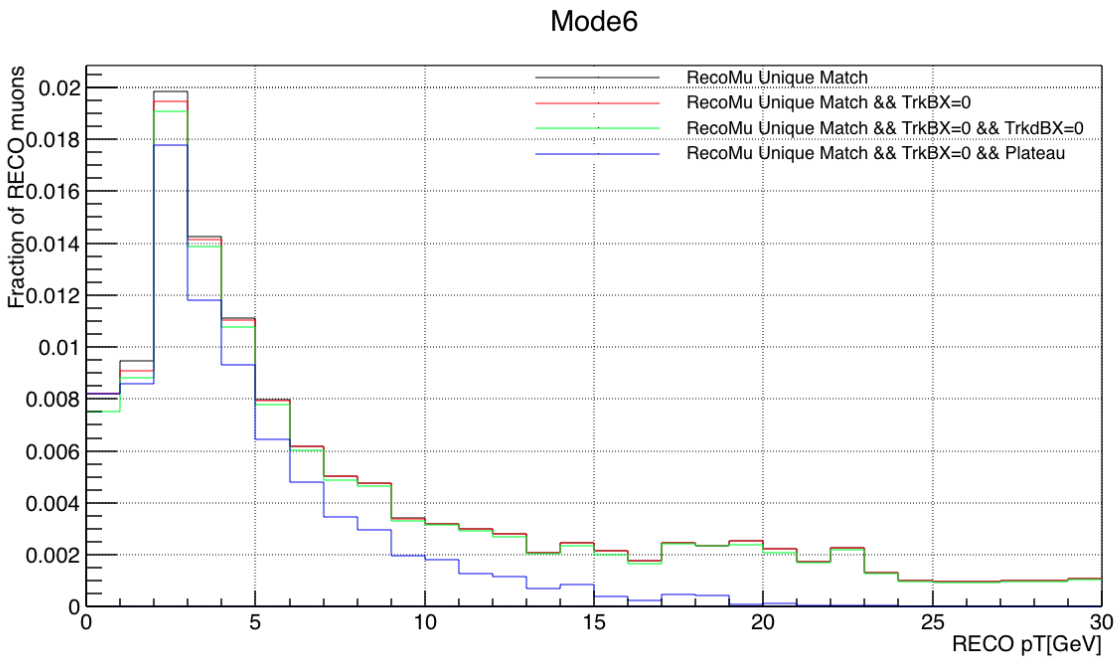
Mode 9 (station 1-4)

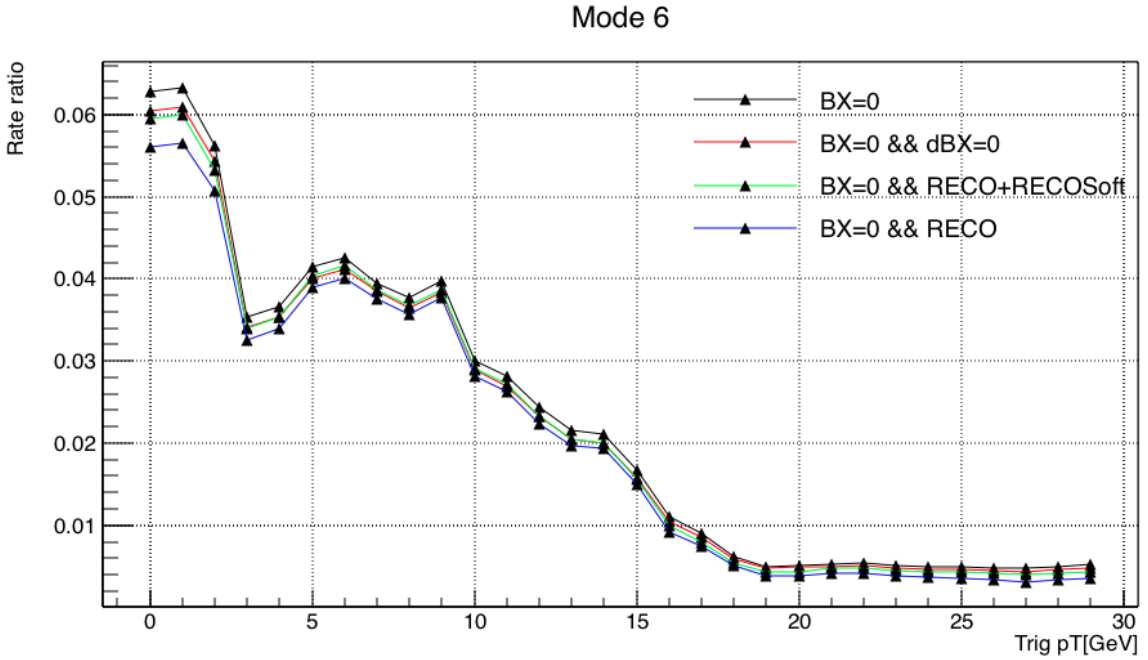




- pT>5 GeV: plateau efficiency is 1000 times smaller than mode 15 (station 1-2-3-4)
- pT>5 GeV: overall contribution to rate is reasonable, but increases from 1.8% - 3.5% as pT increases

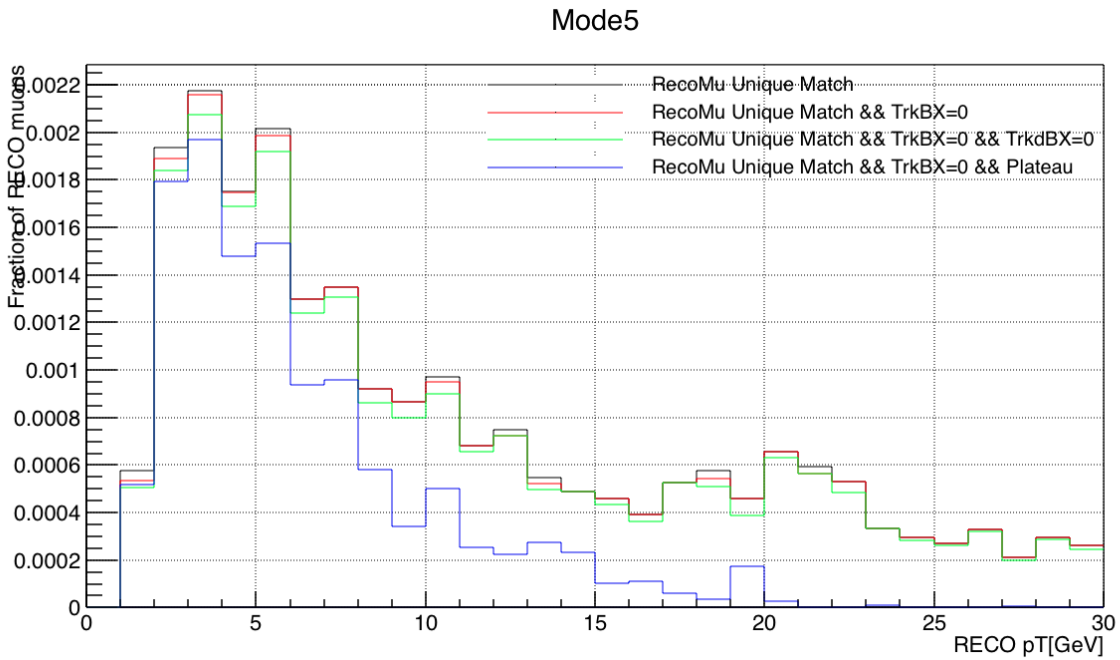
Mode 6 (station 2-3)

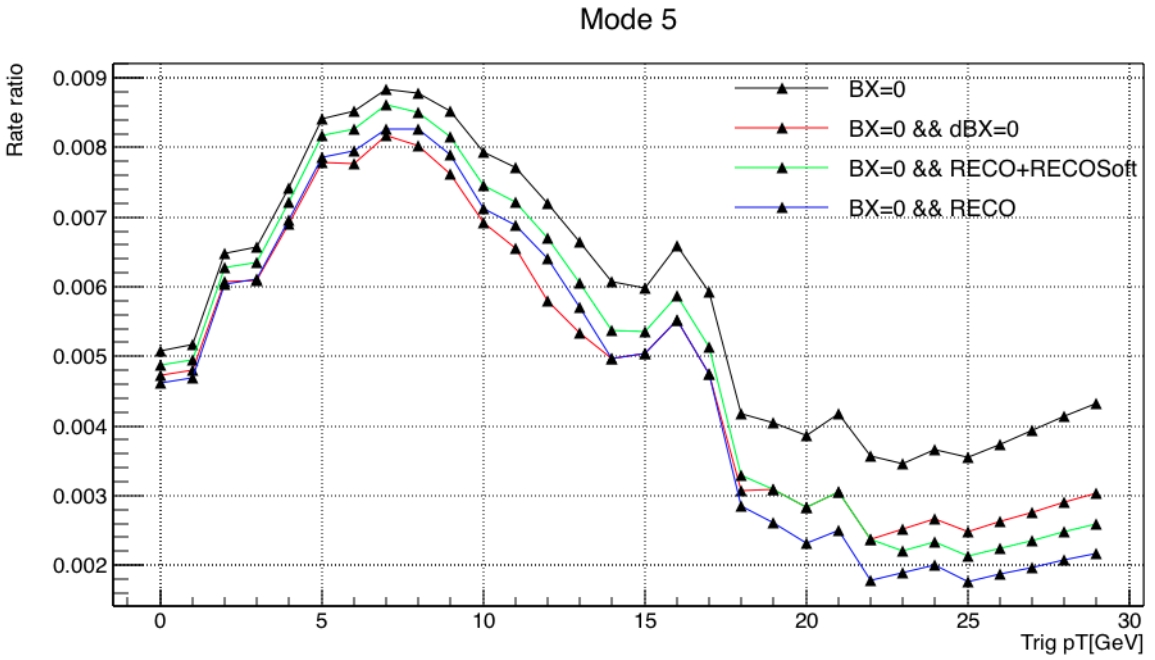




- pT>5 GeV: plateau efficiency is 100 times smaller than mode 15 (station 1-2-3-4)
- pT>5 GeV: overall contribution to rate is reasonable, 4% - 0.5% as pT increases

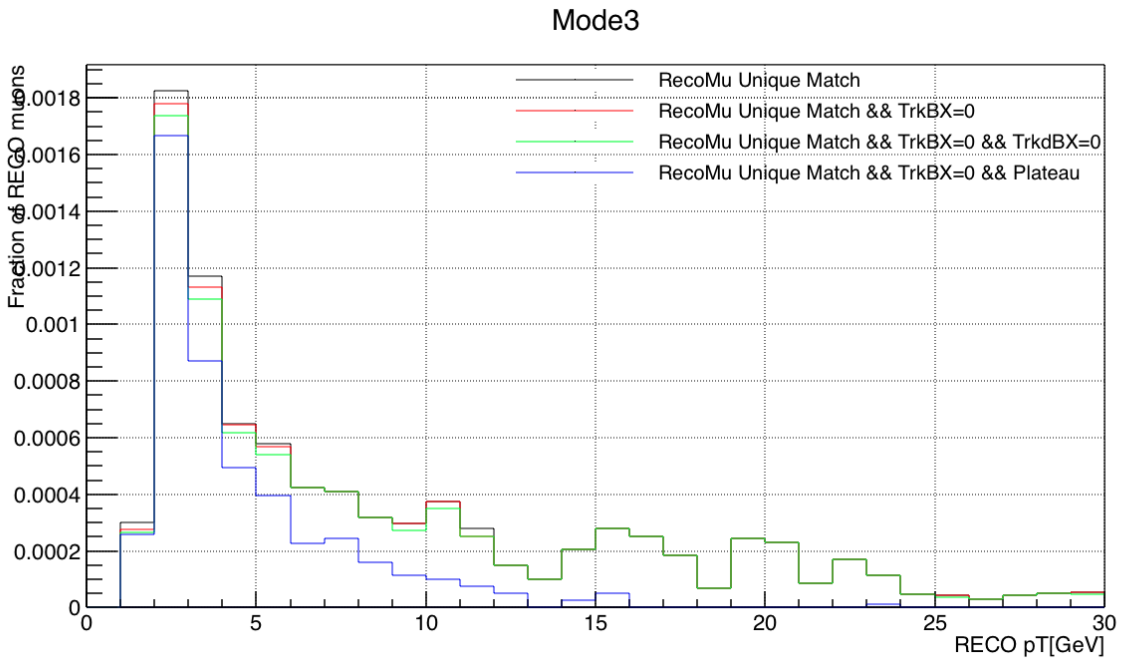
Mode 5 (station 2-4)

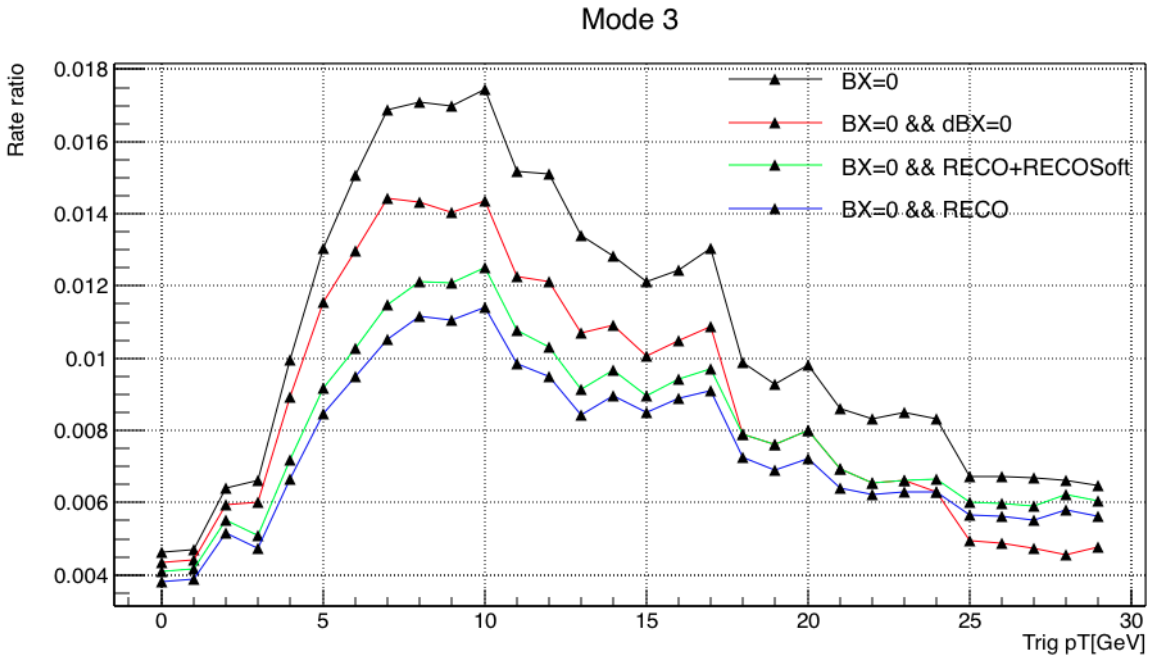




- pT > 5 GeV: efficiency is 1000 times smaller than mode 15 (station 1-2-3-4)
- pT > 5 GeV: overall contribution to rate is reasonable, 0.9% - 0.4% as pT increases

Mode 3 (station 3-4)





- pT>5 GeV: efficiency is at least 1000 times smaller than mode 15 (station 1-2-3-4)
- pT>10 GeV: overall contribution to rate is reasonable, 1.7% - 0.6% as pT increases

Conclusions

- EMTF builds tracks with very high efficiency and good timing down to pT values of 3 - 5 GeV
- May re-map quality vs. mode - e.g. mode 12 -> MuOpen
  - Reduce rate while barely affecting efficiency
- Could add dBX == 0 requirement for 2-station tracks
  - Again, significant rate reduction for almost no efficiency loss
- Working to tighten dTheta windows between stations in track-building
  - Should help reject EMTF tracks built from multiple different muons in high-PU environment
  - Need to find a working point which will not reduce efficiency, even for fairly low-pT muons (5 - 10 GeV)

Back Up

Data Files

root://eoscms.cern.ch//store/user/abrinke1/EMTF/Emulator/ntuples/HADD/

- SingleMu
  - NTuple_SingleMuon_FlatNtuple_Run_306092_2018_03_02_SingleMu.root
  - NTuple_SingleMuon_FlatNtuple_Run_306135_2018_03_02_SingleMu.root
  - NTuple_SingleMuon_FlatNtuple_Run_306154_2018_03_02_SingleMu.root
- Zerobias
  - NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_03_02_ZB1.root
  - NTuple_ZeroBias2_FlatNtuple_Run_306091_2018_03_02_ZB2.root
  - NTuple_ZeroBias3_FlatNtuple_Run_306091_2018_03_02_ZB3.root
  - NTuple_ZeroBias4_FlatNtuple_Run_306091_2018_03_02_ZB4.root

Codes

- EMTF tracks
  - https://github.com/abrinke1/EMTFAnalyzer/blob/master/NTupleMaker/src/FlatNtupleBranches/EMTFTrackInfo.cc
- RECO muons
  - https://github.com/abrinke1/EMTFAnalyzer/blob/master/NTupleMaker/src/FlatNtupleBranches/RecoMuonInfo.cc
- RECO muon-EMTF track dR match
  - https://github.com/abrinke1/EMTFAnalyzer/blob/master/NTupleMaker/src/FlatNtupleMatchers/RecoTrkDR.cc
- Macro
  - https://github.com/weishi10141993/EMTF_CSCTF_pTResolution_TrackBuild_dR_Matching/blob/master/ModesRateEff.C