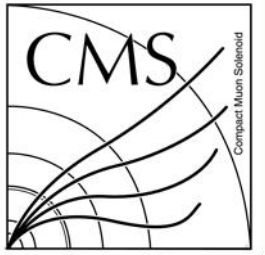


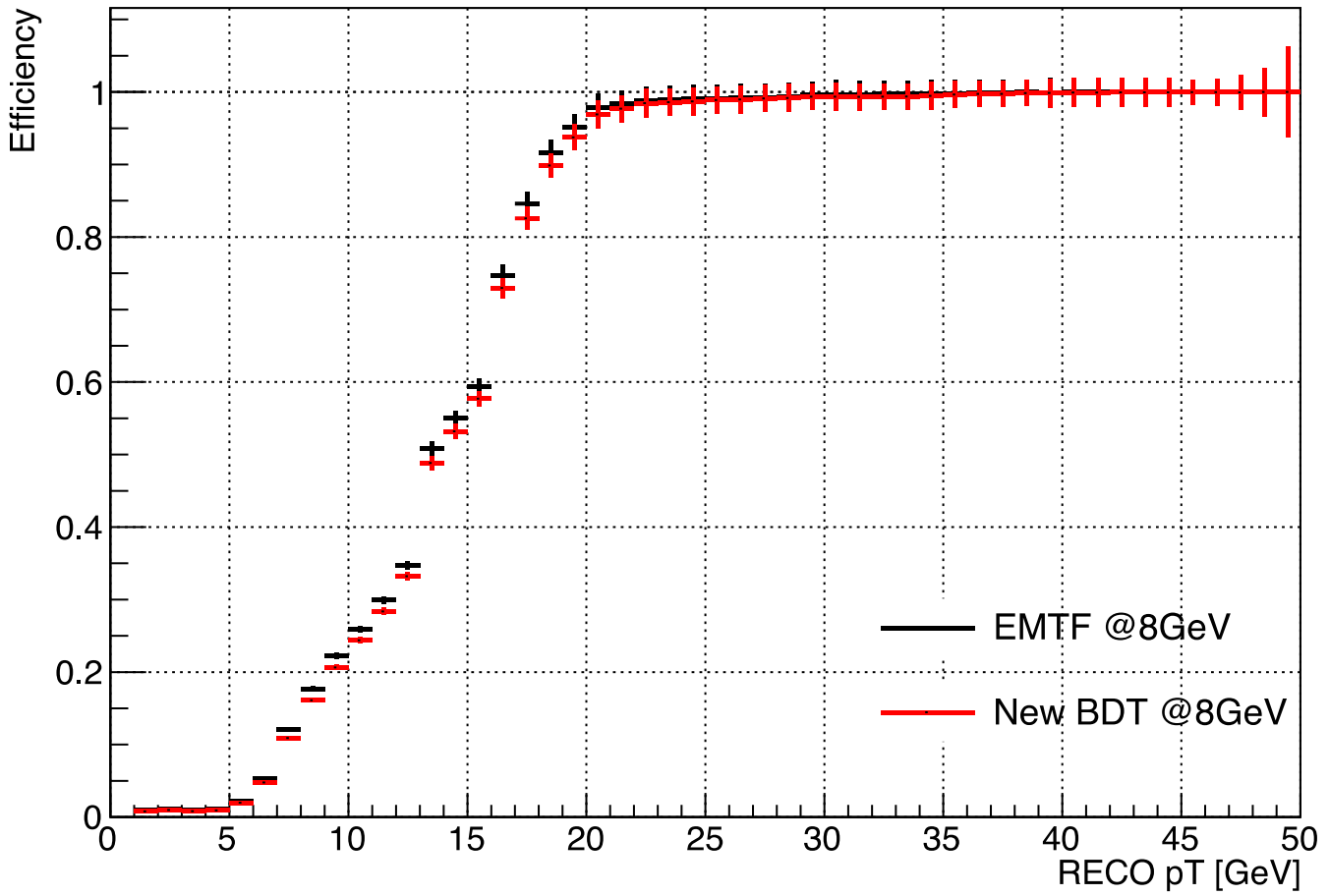
First Results Training pT with Data

Wei Shi

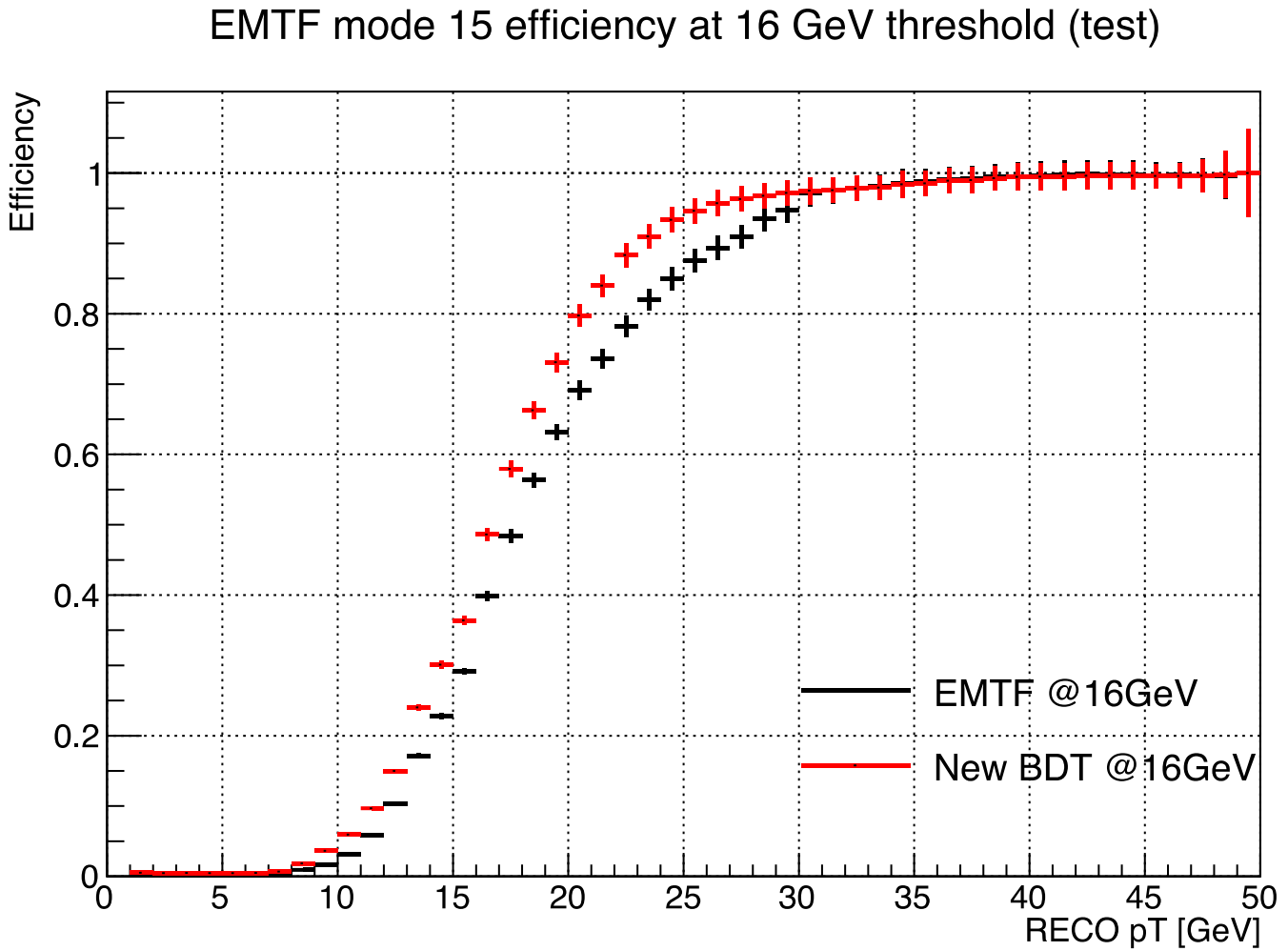
Basics

- Train 22,824 muons
  - SingleMu Ntuple
    - NTuple_SingleMuon_FlatNtuple_Run_2018D_v2_2018_10_25_SingleMuon_PU50_postSep26.root
  - EMTF track uniquely matched to RECO muon + Current P5 BDT pT as input
  - Replace LCT with Offline CSC segments for phi and theta
- Test 38,308 muons
  - SingleMu data (uniquely matched) + ZeroBias
    - NTuple_SingleMuon_FlatNtuple_Run_2018D_v2_2018_10_25_ZeroBias_PU50_postSep26.root
- Settings
  - Removed bias events for training and test
    - Removed events: nRecoMuonsTrig<2 && nRecoMuonsTrigCen==0
  - logPt target, 1/pT weight, Least Square loss function
  - 400 trees

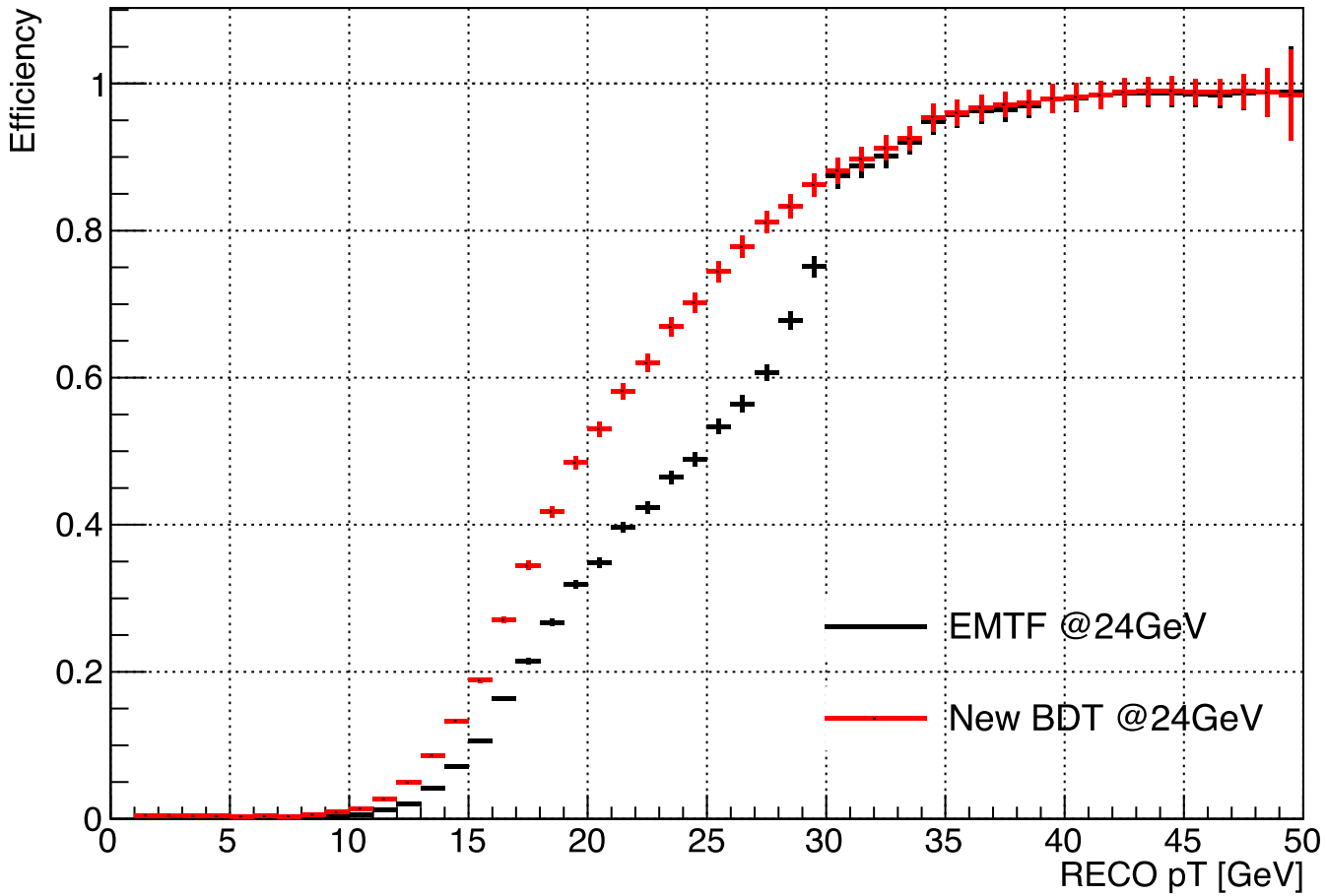
Efficiency @ 8GeV



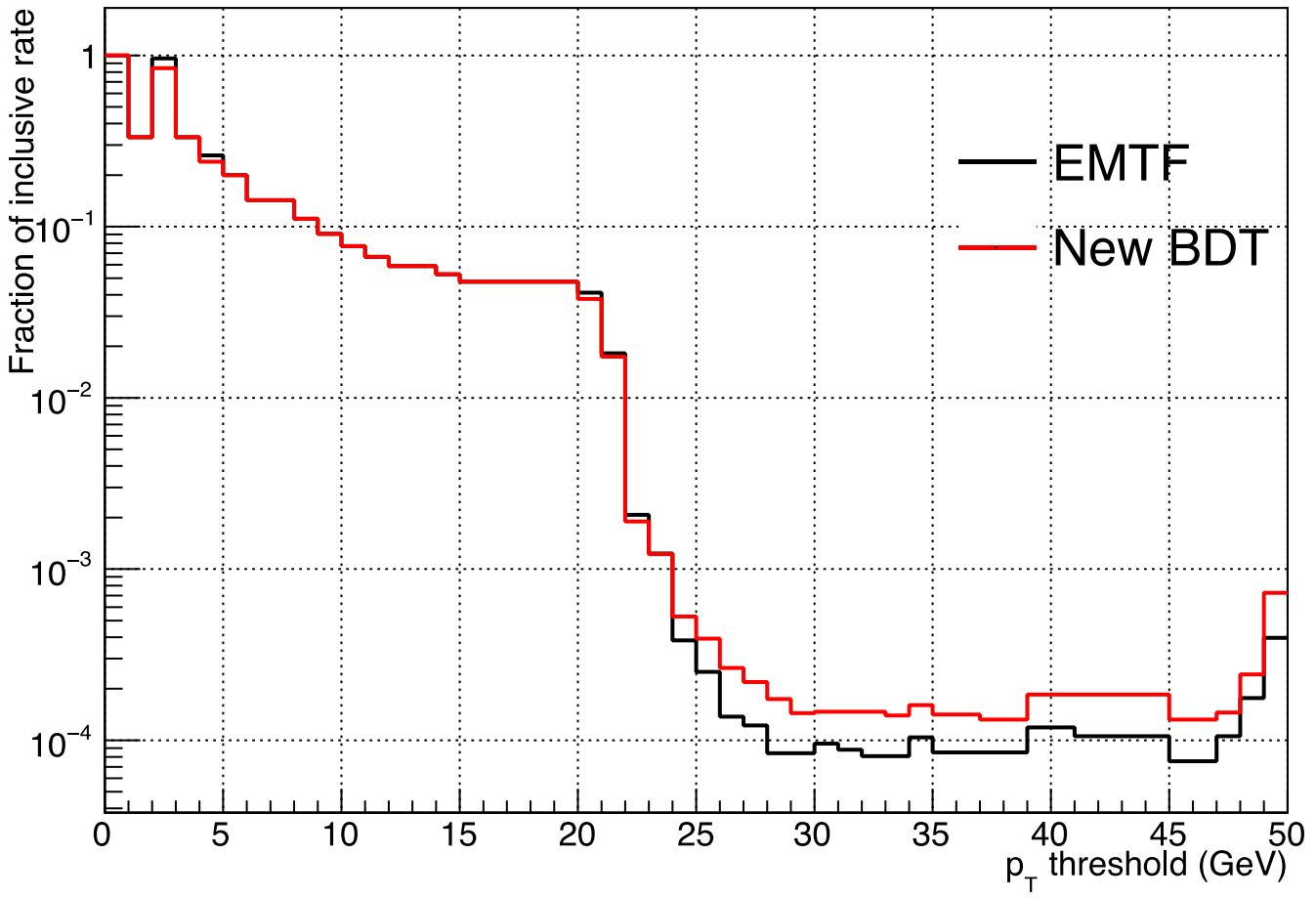
Efficiency @ 16GeV



Efficiency @ 24GeV



Rate

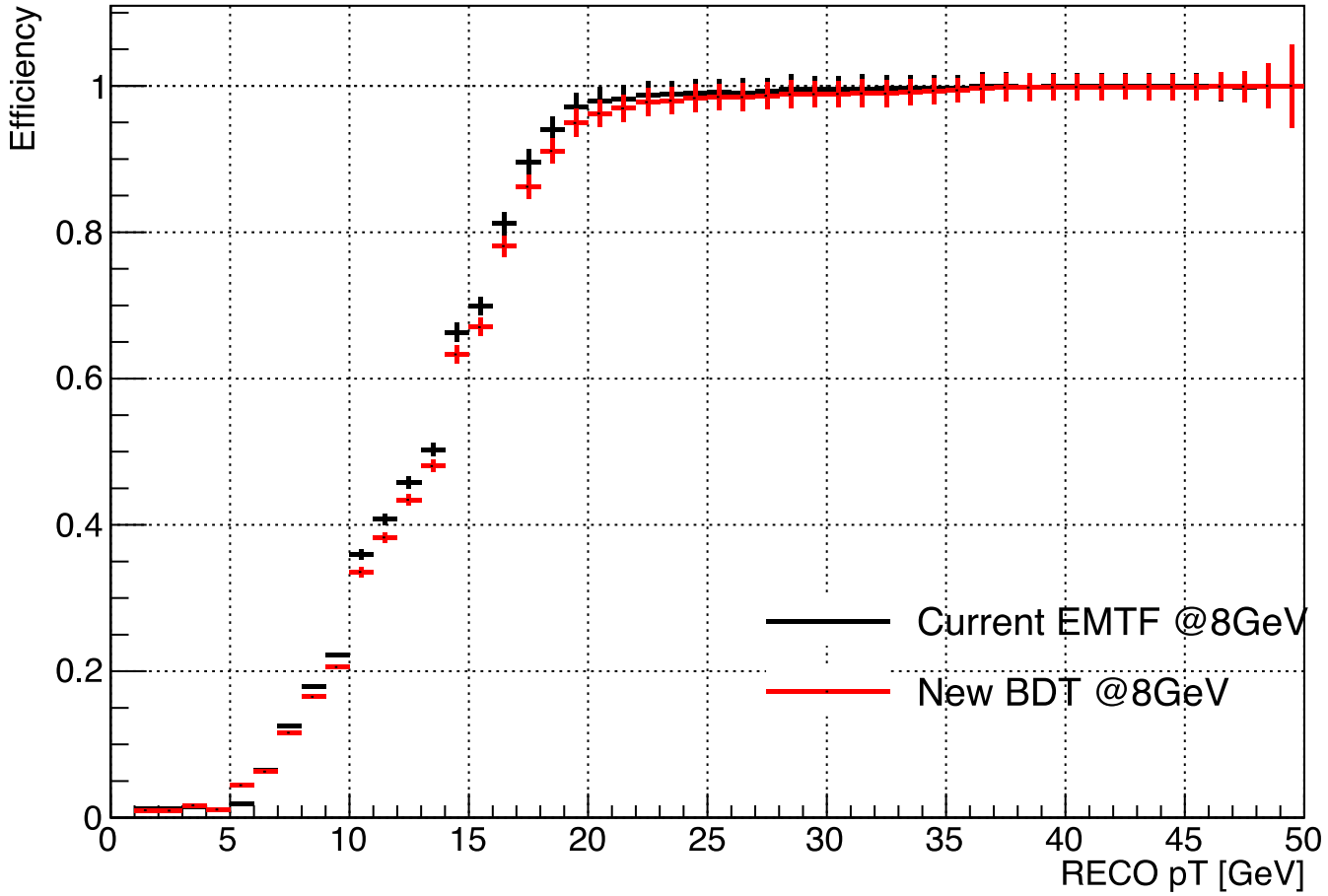

Fraction of inclusive rate
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
5
10
15
20
25
30
35
40
45
50
p_T threshold (GeV)
EMTF
New BDT

Back Up

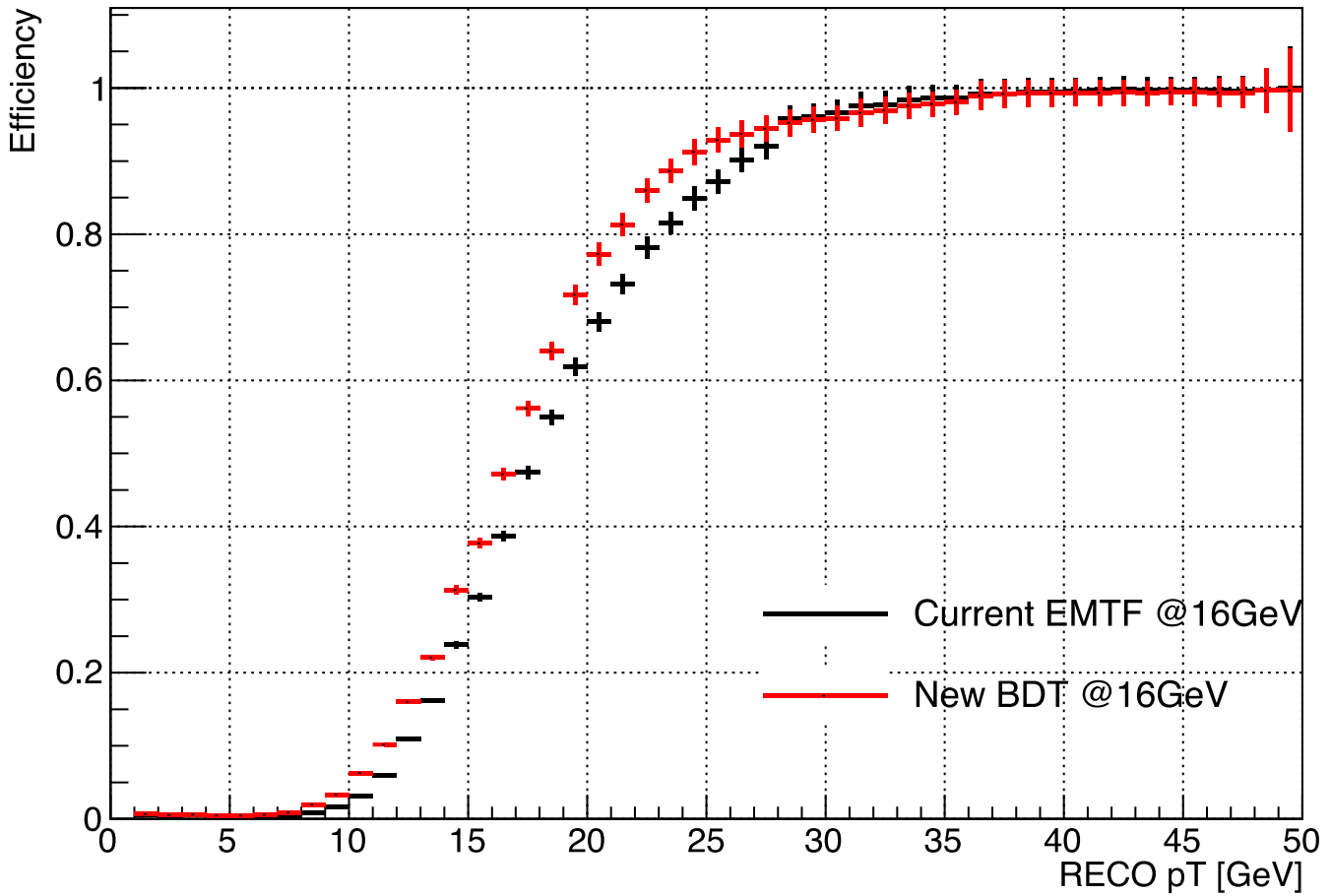
Basics

- Train 29,428 muons
  - SingleMu Ntuple
    - NTuple_SingleMuon_FlatNtuple_Run_2018D_v2_2018_10_25_SingleMuon_PU50_postSep26.root
  - EMTF track uniquely matched to RECO muon + Current P5 BDT pT as input
  - Removed bias in SingleMu data
    - Removed events: nRecoMuonsTrig==1 && nRecoMuonsTrigCen==0
- Test 53,514 muons
  - SingleMu data (uniquely matched) + ZeroBias
    - NTuple_SingleMuon_FlatNtuple_Run_2018D_v2_2018_10_25_ZeroBias_PU50_postSep26.root
- Settings
  - logPt target, 1/pT weight, Least Square loss function
  - 400 trees

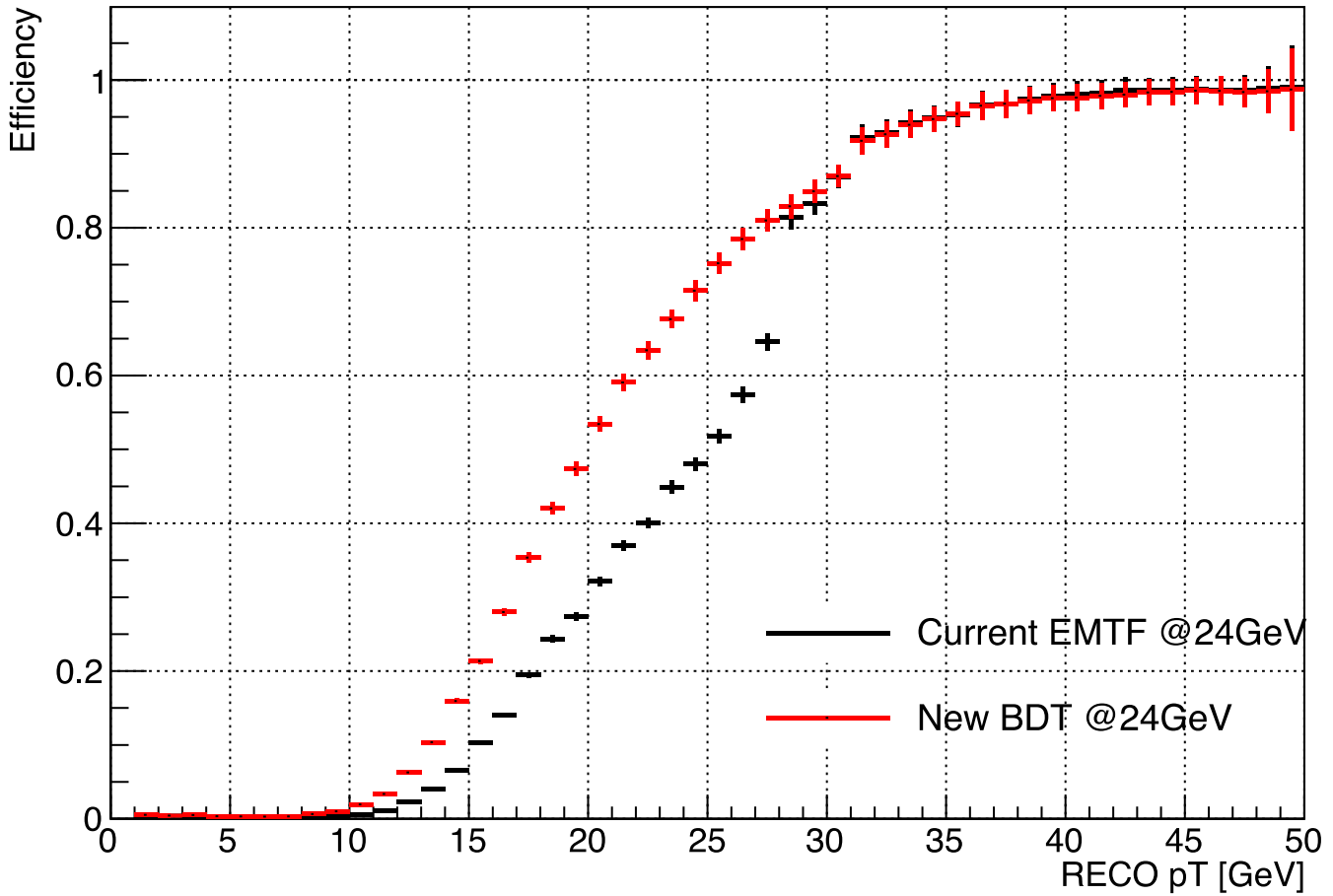
Efficiency @ 8GeV



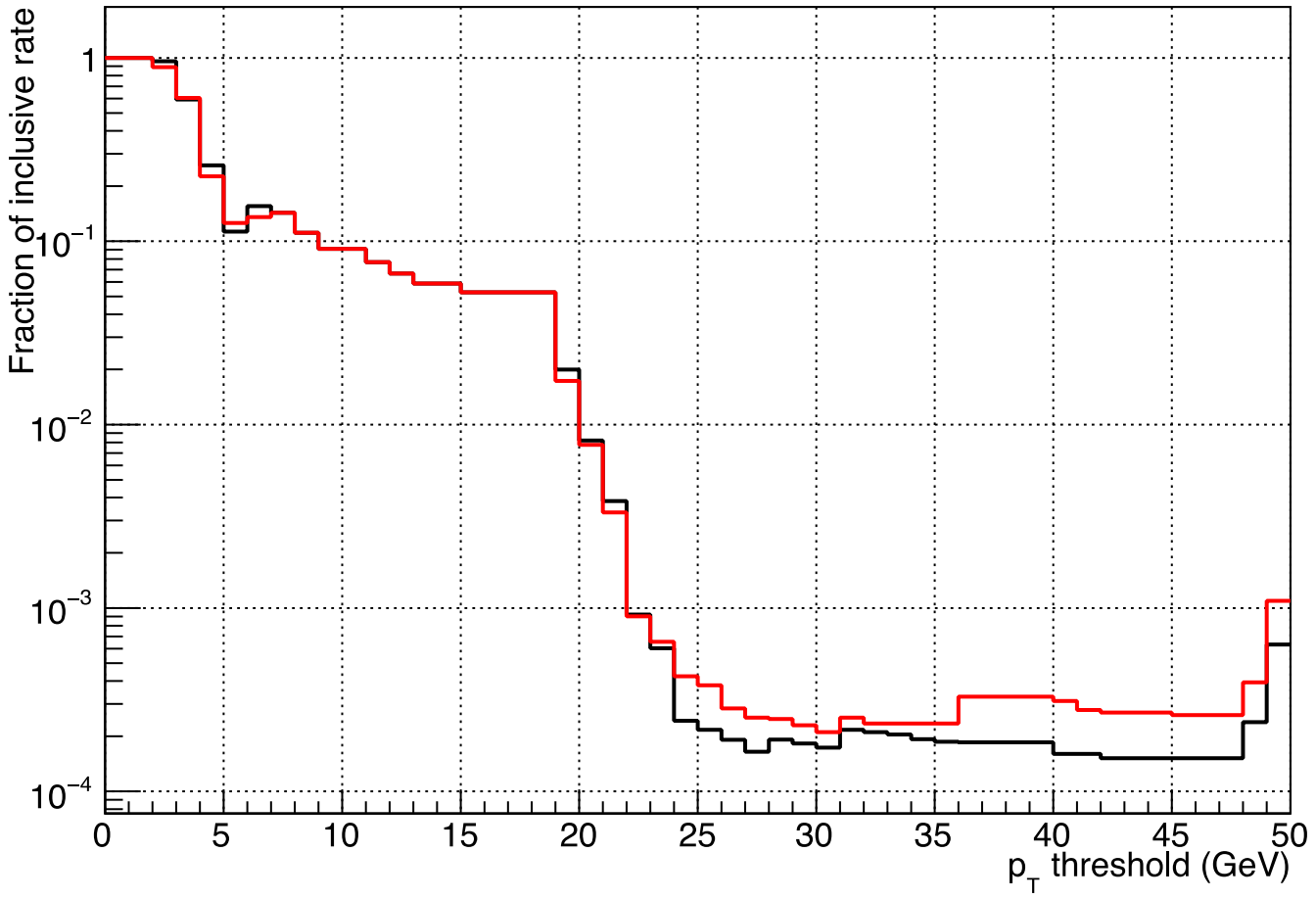
Efficiency @ 16GeV



Efficiency @ 24GeV



Rate

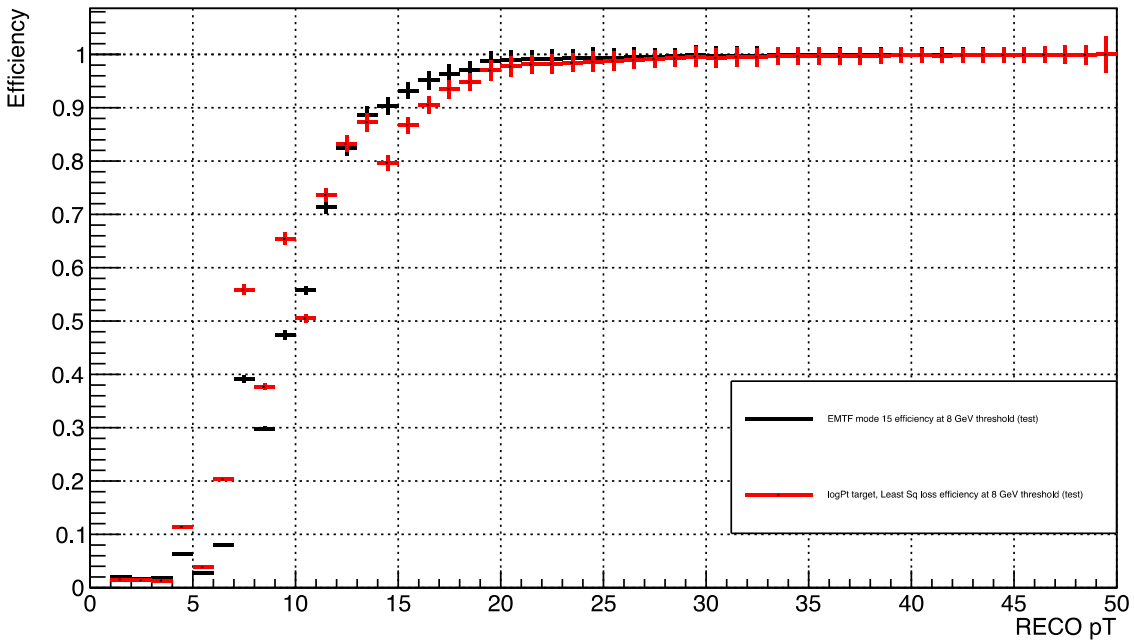

Fraction of inclusive rate
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
5
10
15
20
25
30
35
40
45
50
p_T threshold (GeV)

Back Up

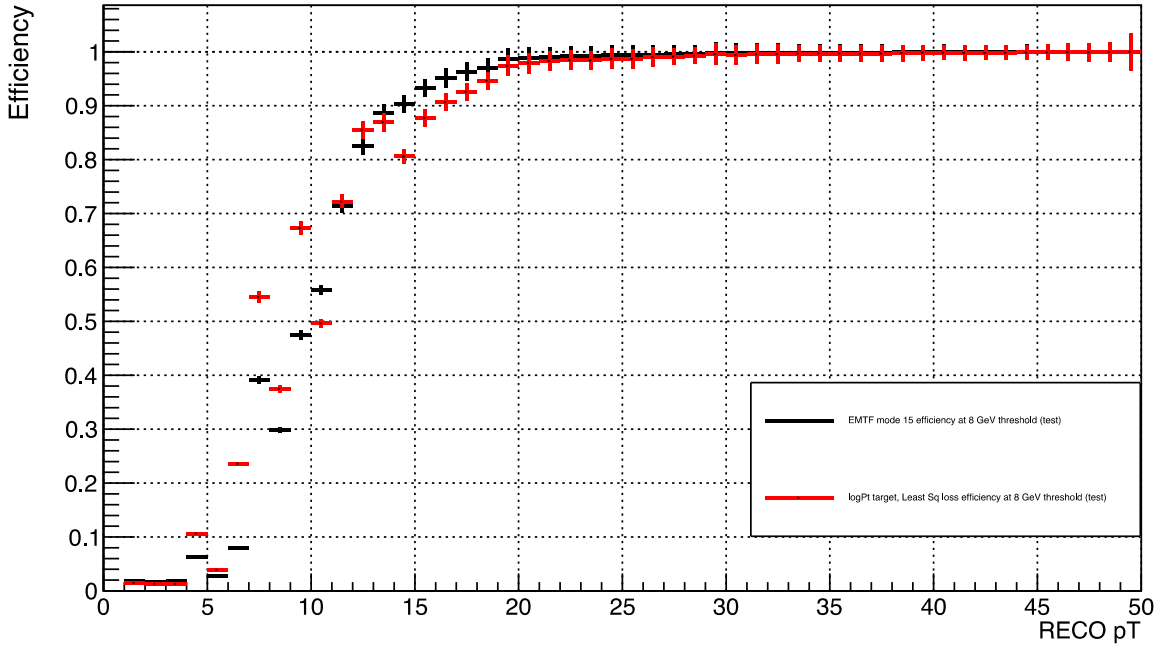
Basics

- Train 87,584 muons
  - SingleMu Ntuple with trigger matching using 2018 dTh4
    - NTuple_SingleMuon_FlatNtuple_Run_306154_2018_05_07_SingleMu_2018_emul_dTh4.root
    - NTuple_SingleMuon_FlatNtuple_Run_306154_2018_05_07_SingleMu_2017_emul.root
  - EMTF track uniquely matched to RECO muon + 2017 BDT pT as input
  - Removed bias in SingleMu data
    - Removed events: nRecoMuonsTrig==1 && nRecoMuonsTrigCen==0
- Test 207,572 muons
  - SingleMu data (uniquely matched) + ZeroBias
    - NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_05_07_ZB1_2018_emul_dTh4.root
    - NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_05_07_ZB1_2017_emul.root
- Settings
  - Compare 100 trees and 400 trees in case of overtraining
  - Compare 2018 dTh4 and 2017 setting
  - logPt target, 1/pT weight, Least Square loss function

2018 dTh4 Efficiency @ 8GeV

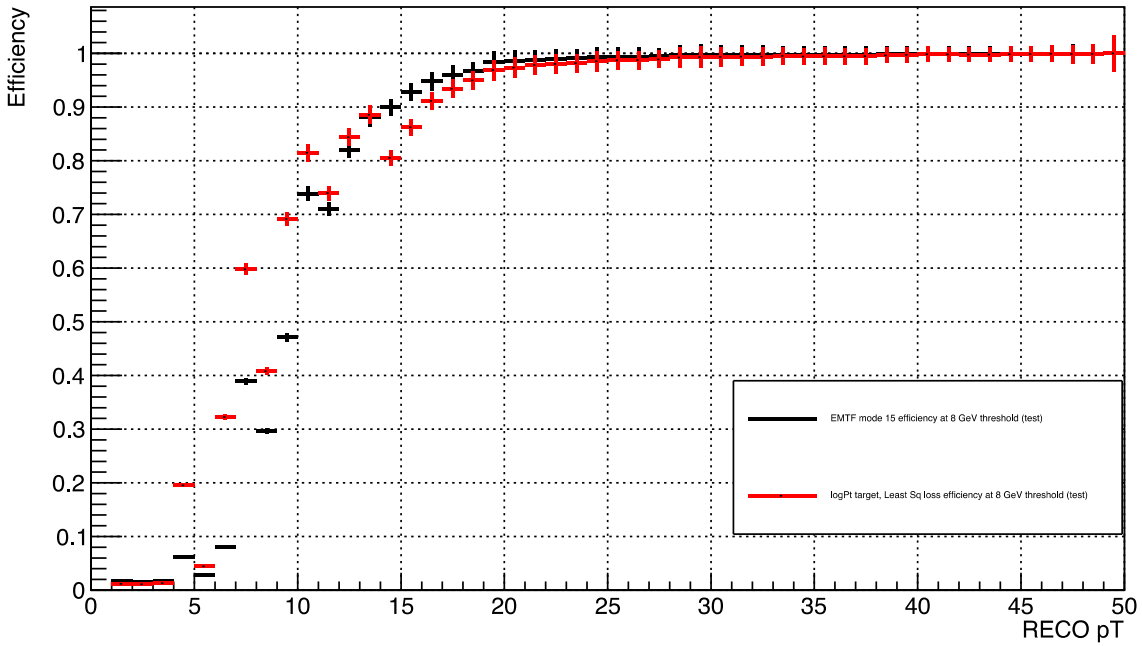


400 Trees

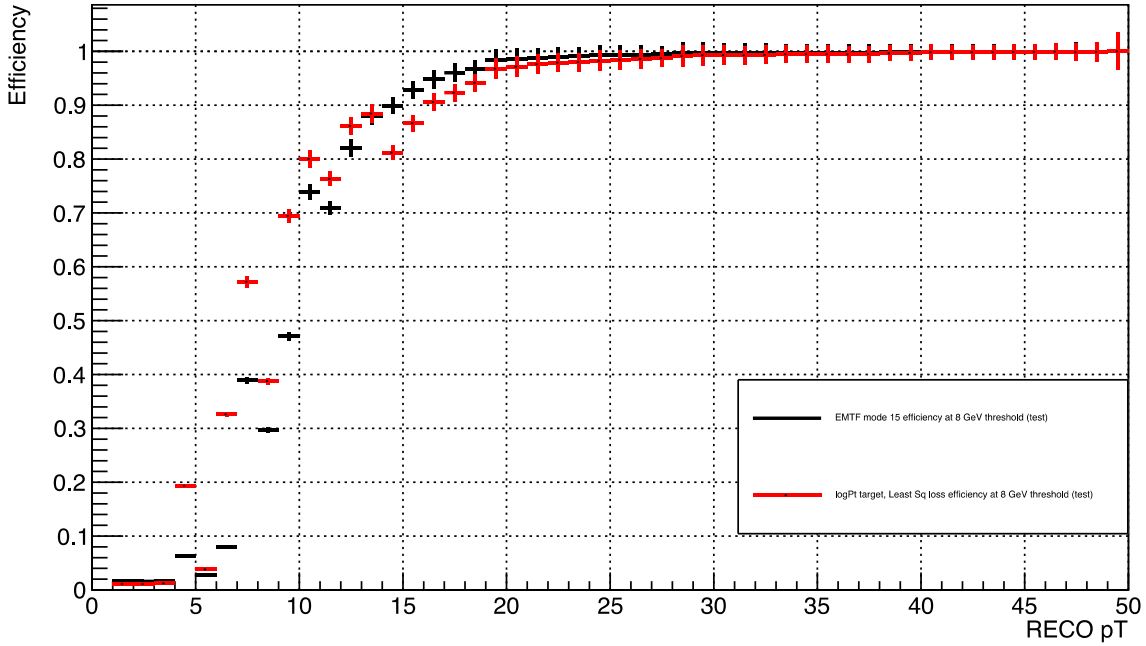


100 Trees

2017 Efficiency @ 8GeV

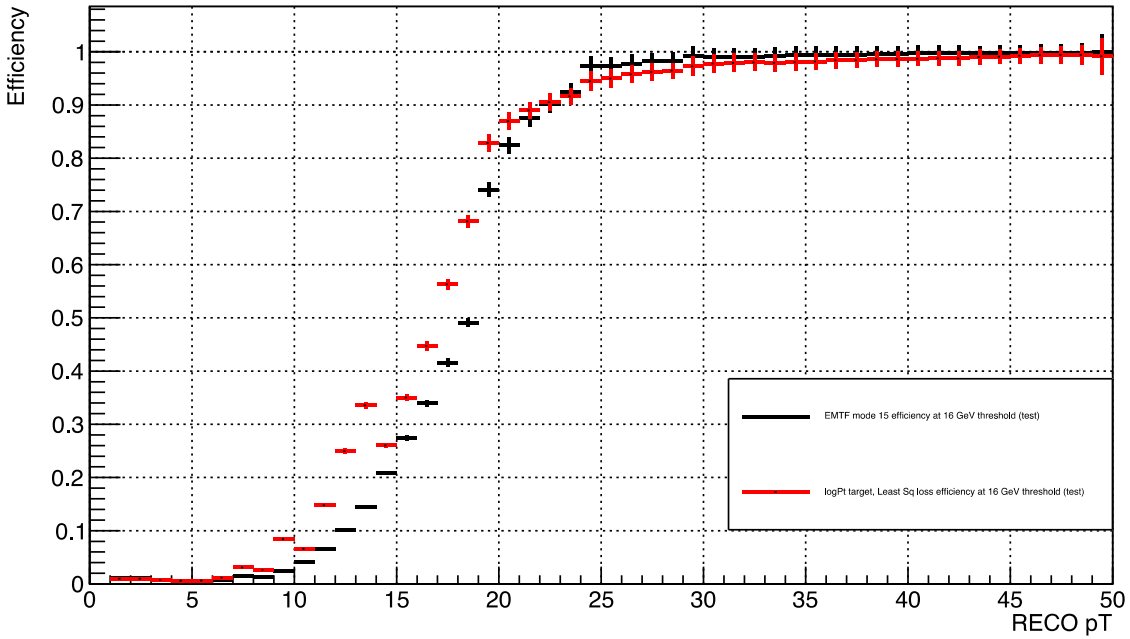


400 Trees

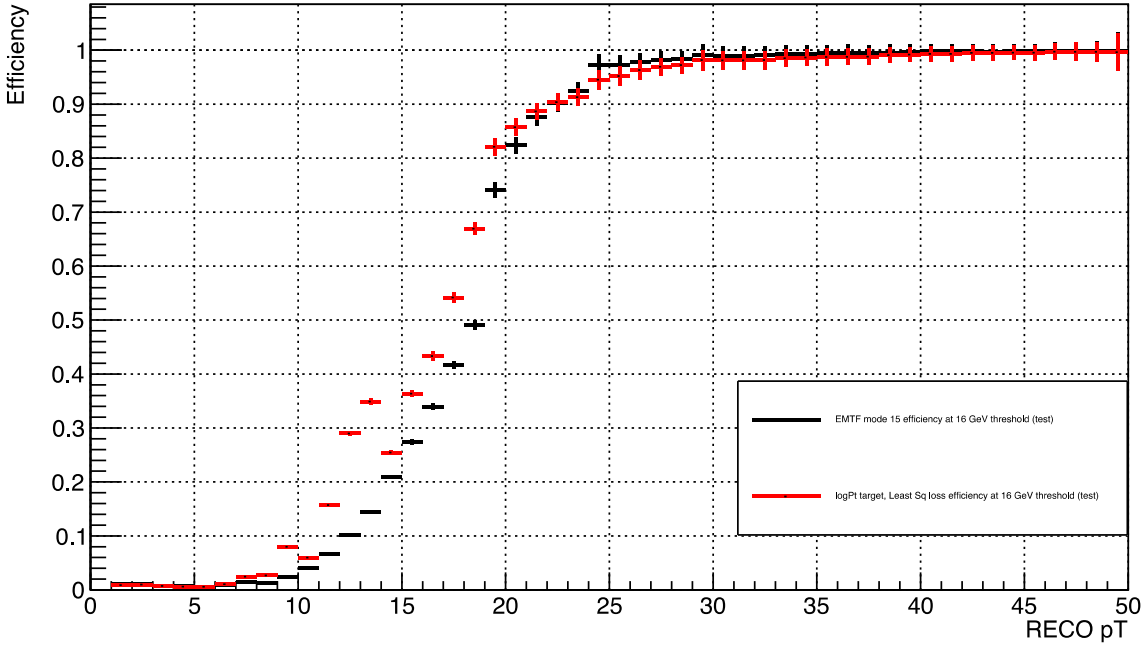


100 Trees

2018 dTh4 Efficiency @ 16GeV

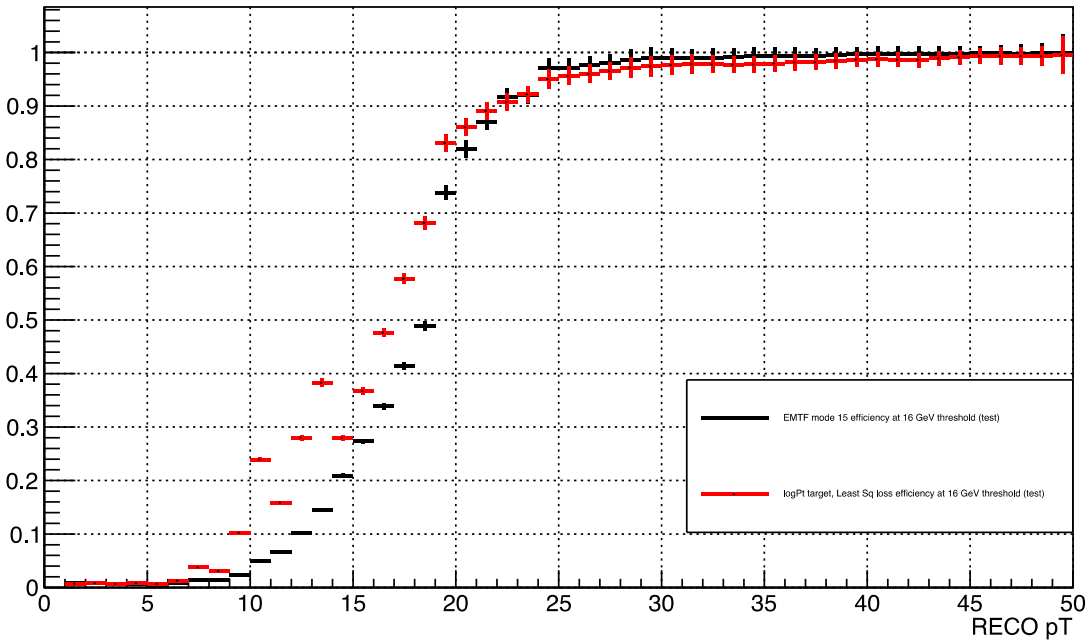


400 Trees

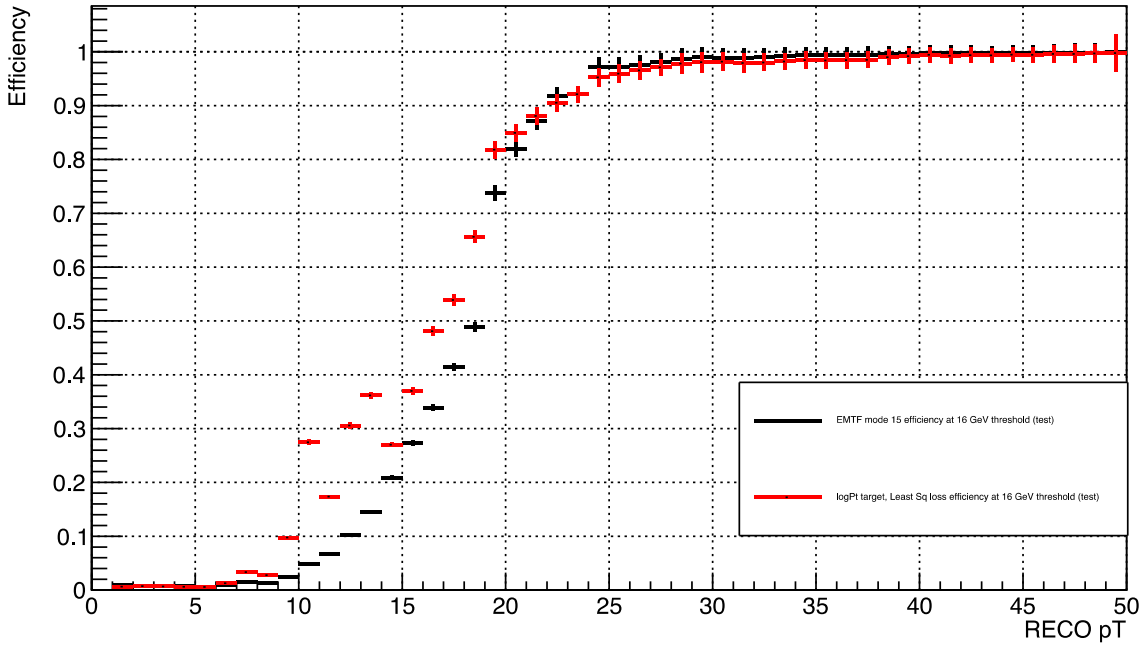


100 Trees

2017 Efficiency @ 16GeV

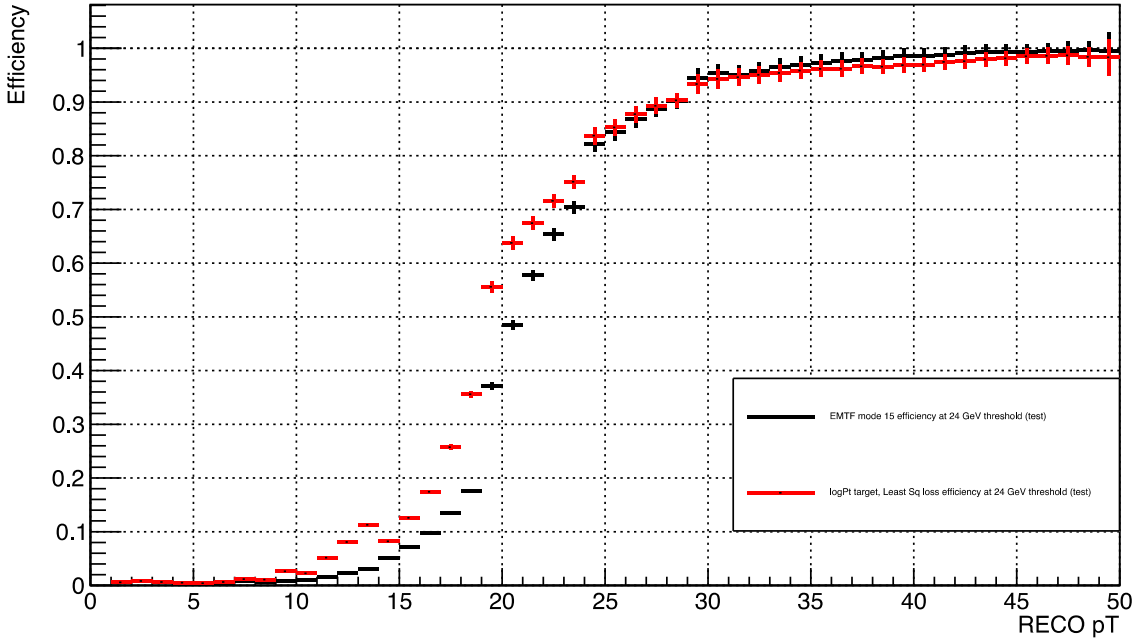


400 Trees

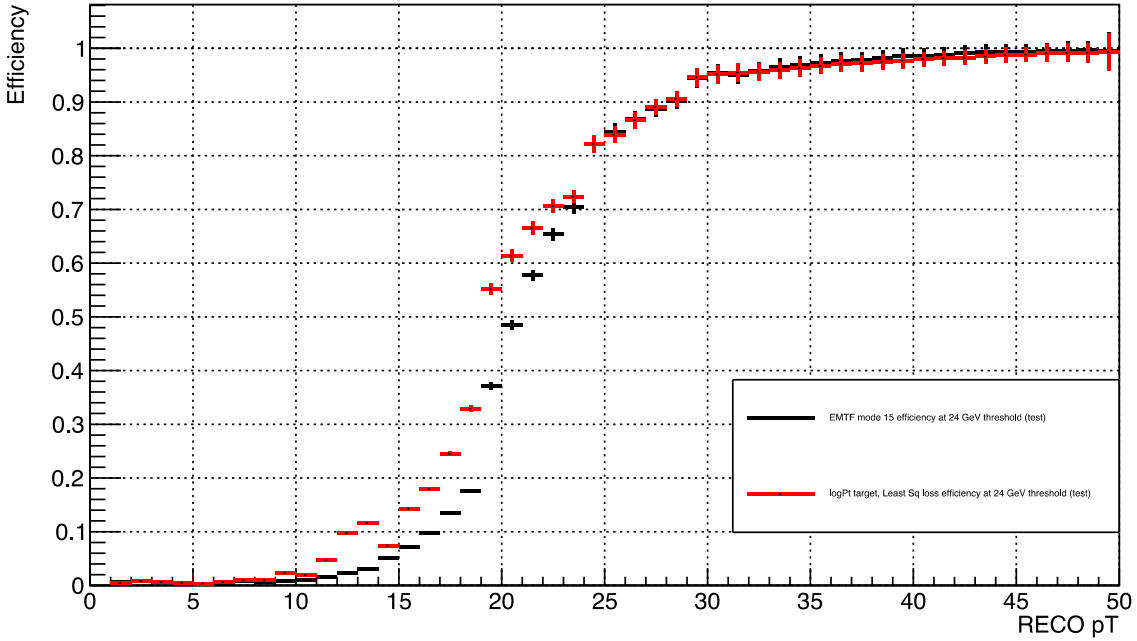


100 Trees

2018 dTh4 Efficiency @ 24GeV

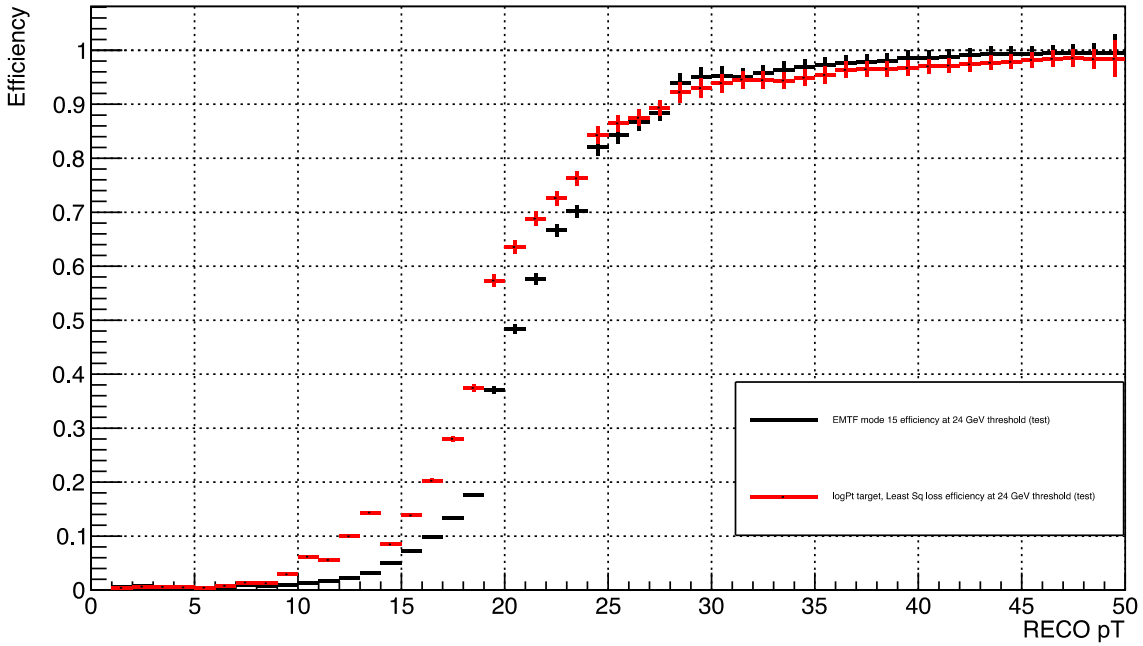


400 Trees

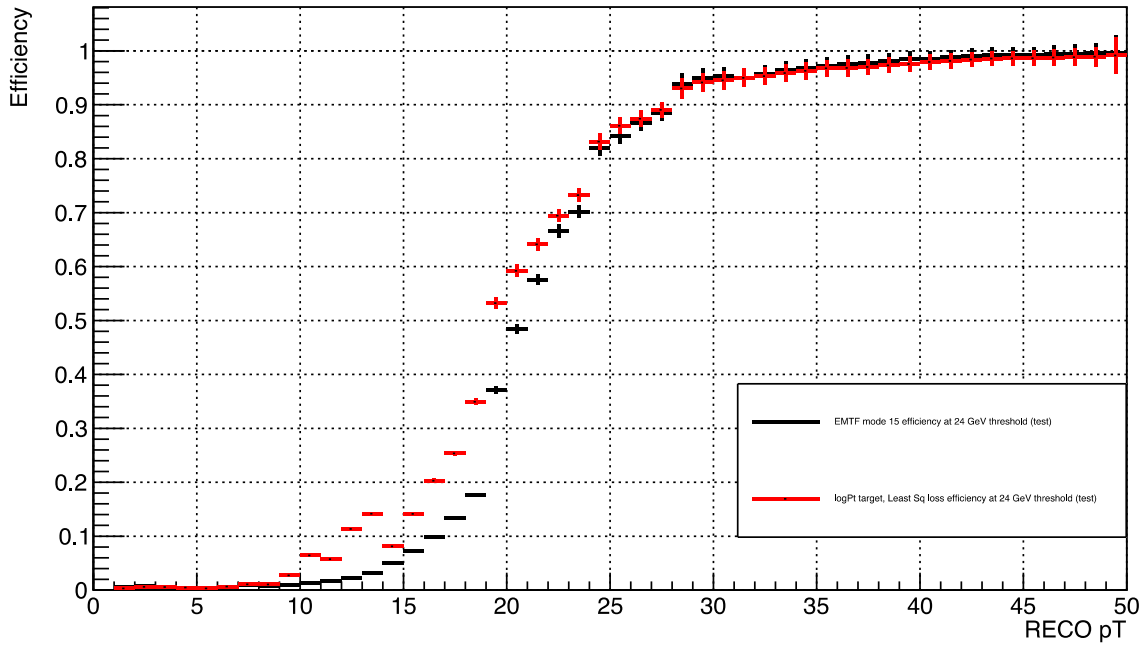


100 Trees

2017 Efficiency @ 24GeV

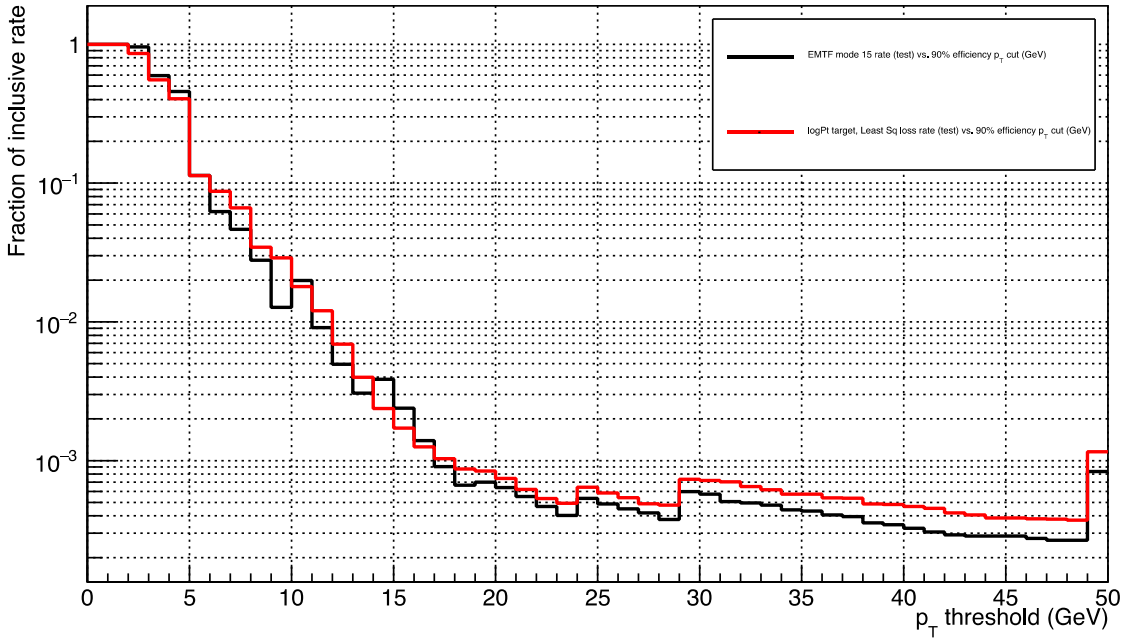


400 Trees

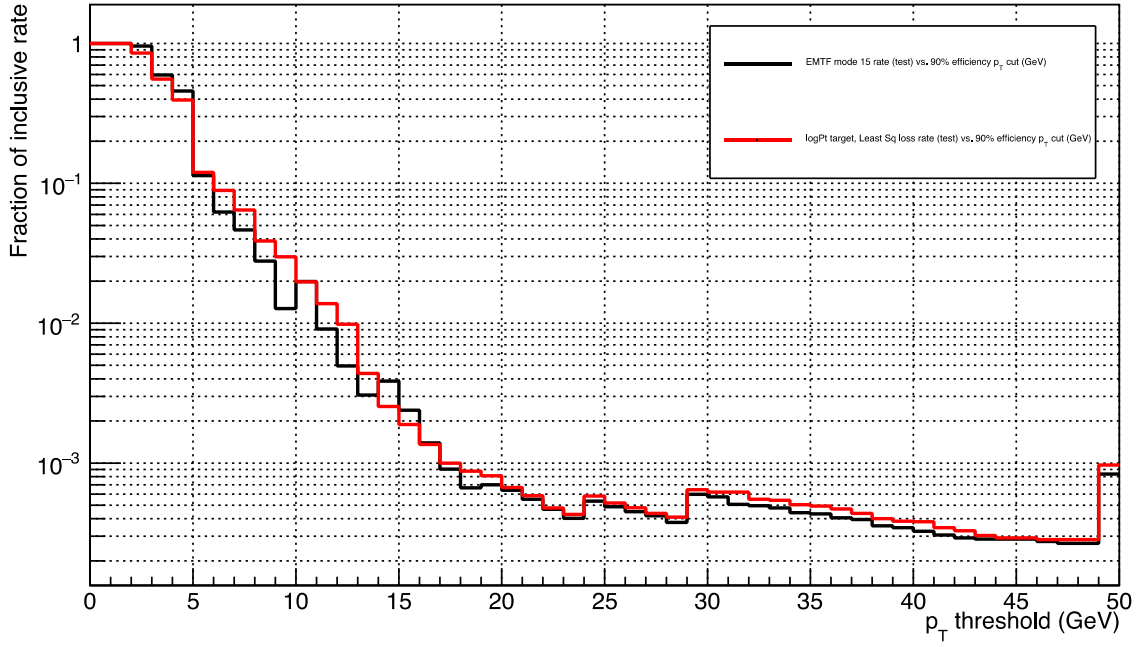


100 Trees

2018 dTh4 setting: Rate

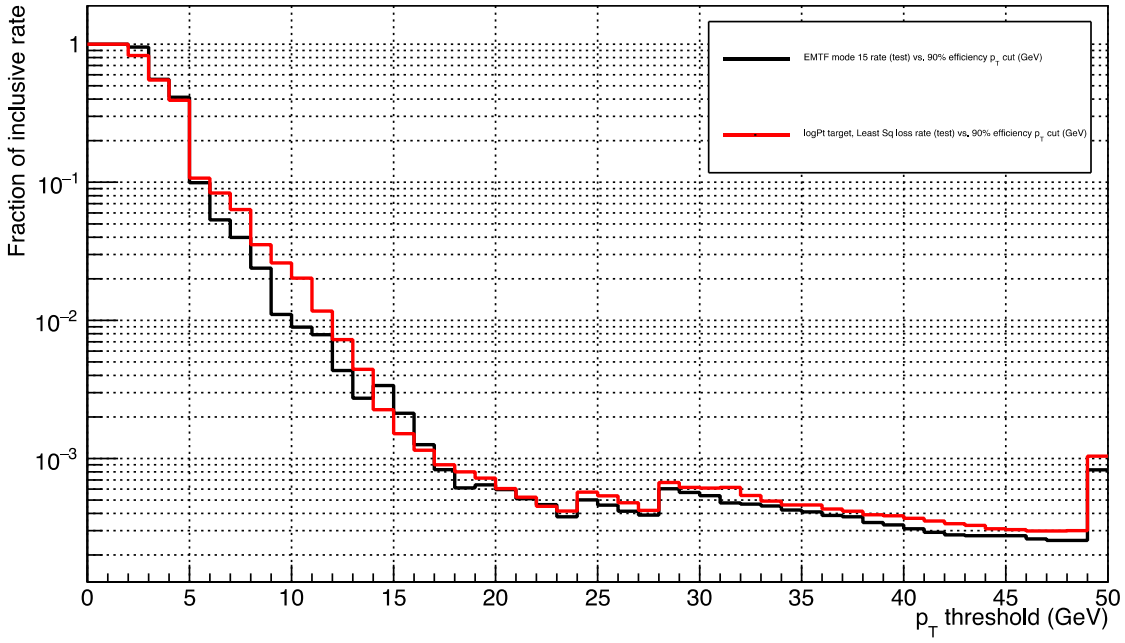


400 Trees

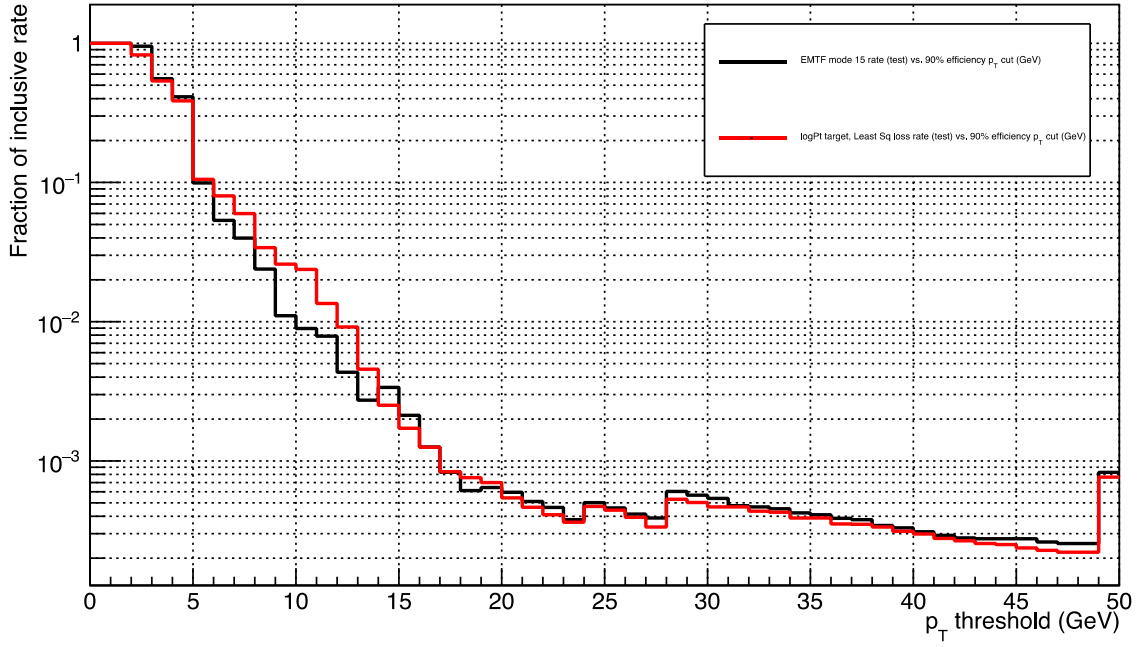


100 Trees

2017 setting: Rate



400 Trees



100 Trees

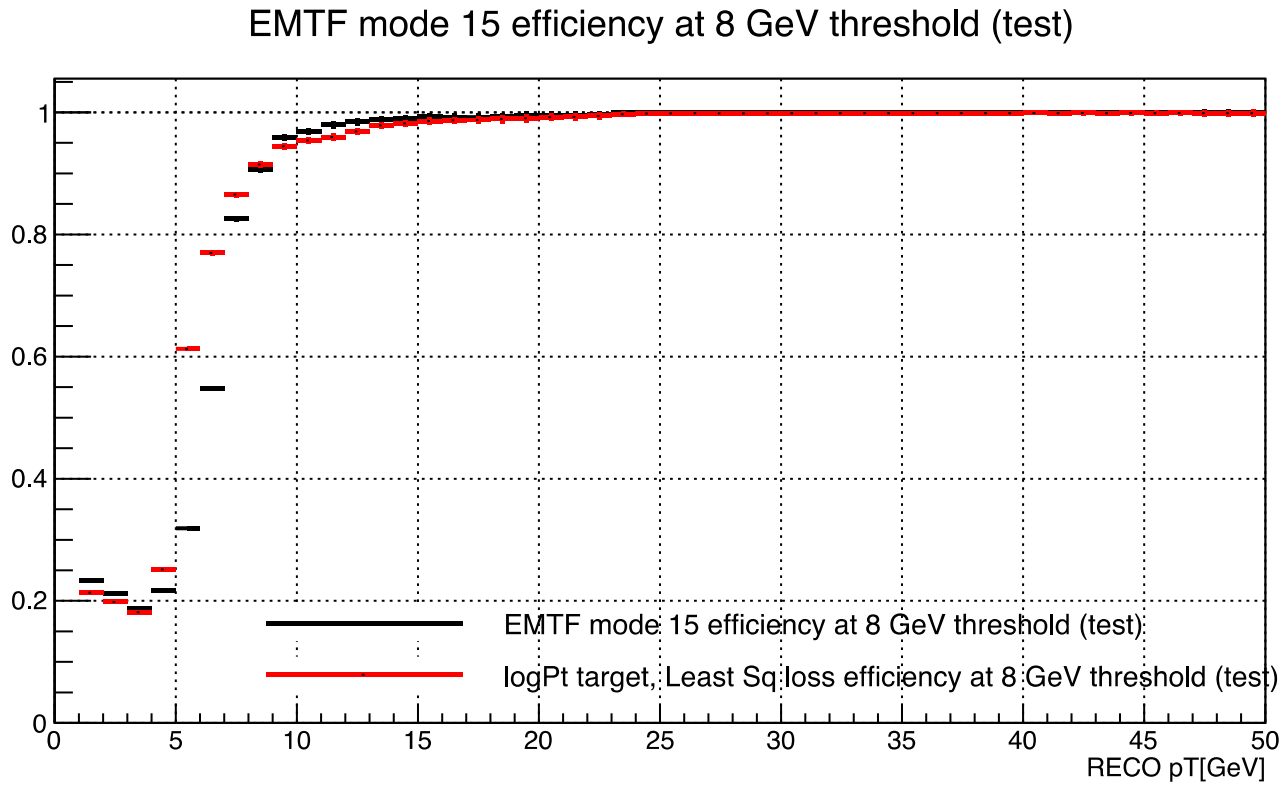
Back Up

Basics

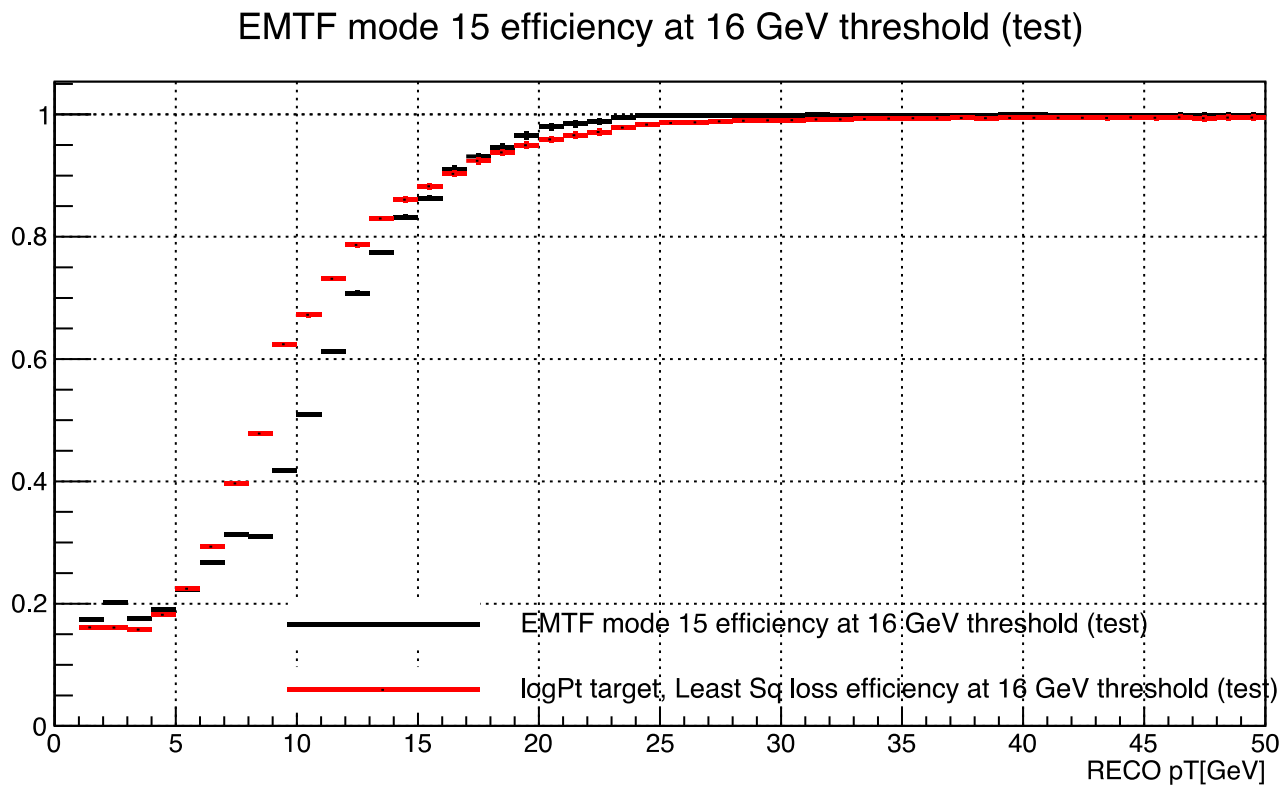
- Train 85,265 muons
  - SingleMu data
  - EMTF track uniquely matched to RECO muon + 2017 BDT pT as input
  - Removed bias in SingleMu data [1]
    - Removed events with only 1 EMTF muon in endcap [2]
- Test 7,017,799 muons
  - SingleMu data (uniquely matched) + ZeroBias
- Settings
  - logPt target, 1/pT weight, Least Square loss function
  - Other BDT parameters same to 2017 BDT setting

[1] Slide 6, https://twiki.cern.ch/twiki/pub/CMS/EMTFAnalyzer/EMTF_Studies_on_Reco_Muons.pdf
[2] https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C#L412-L432

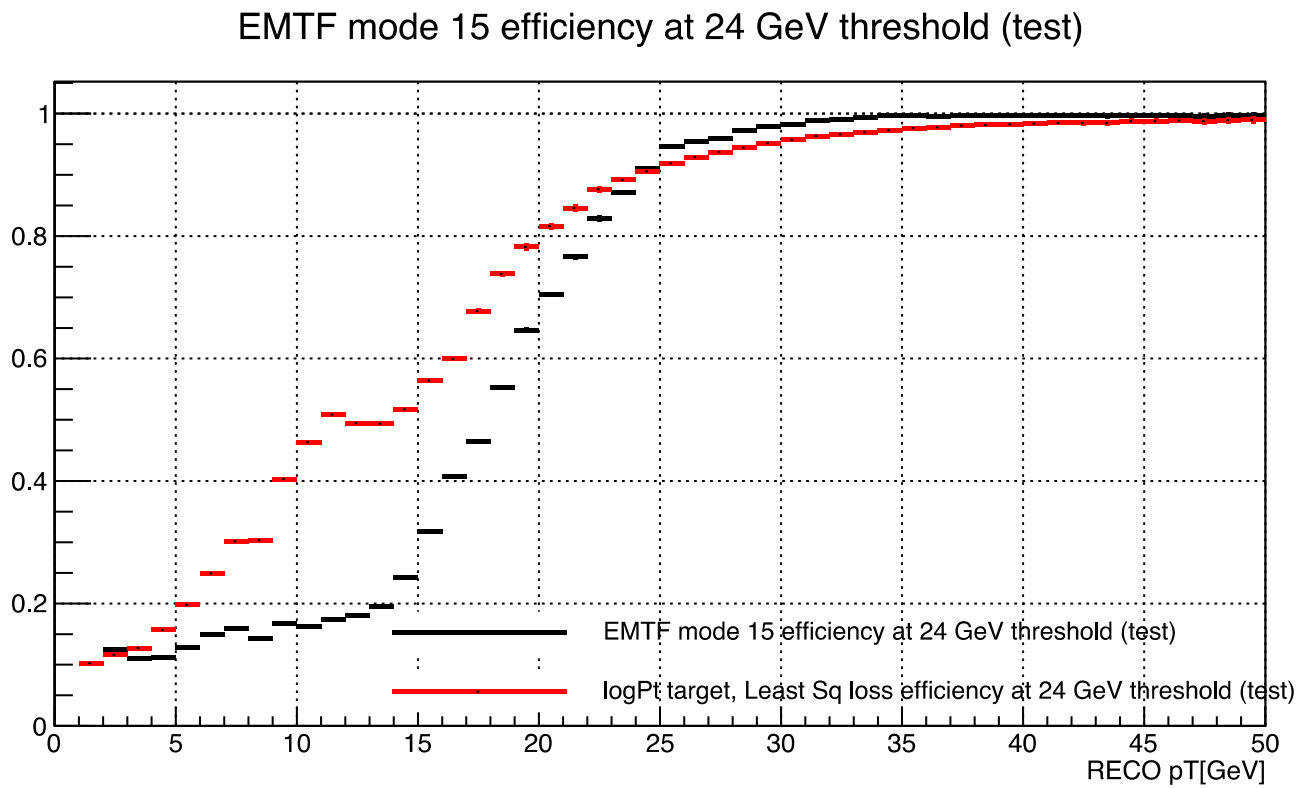
Efficiency @ 8GeV



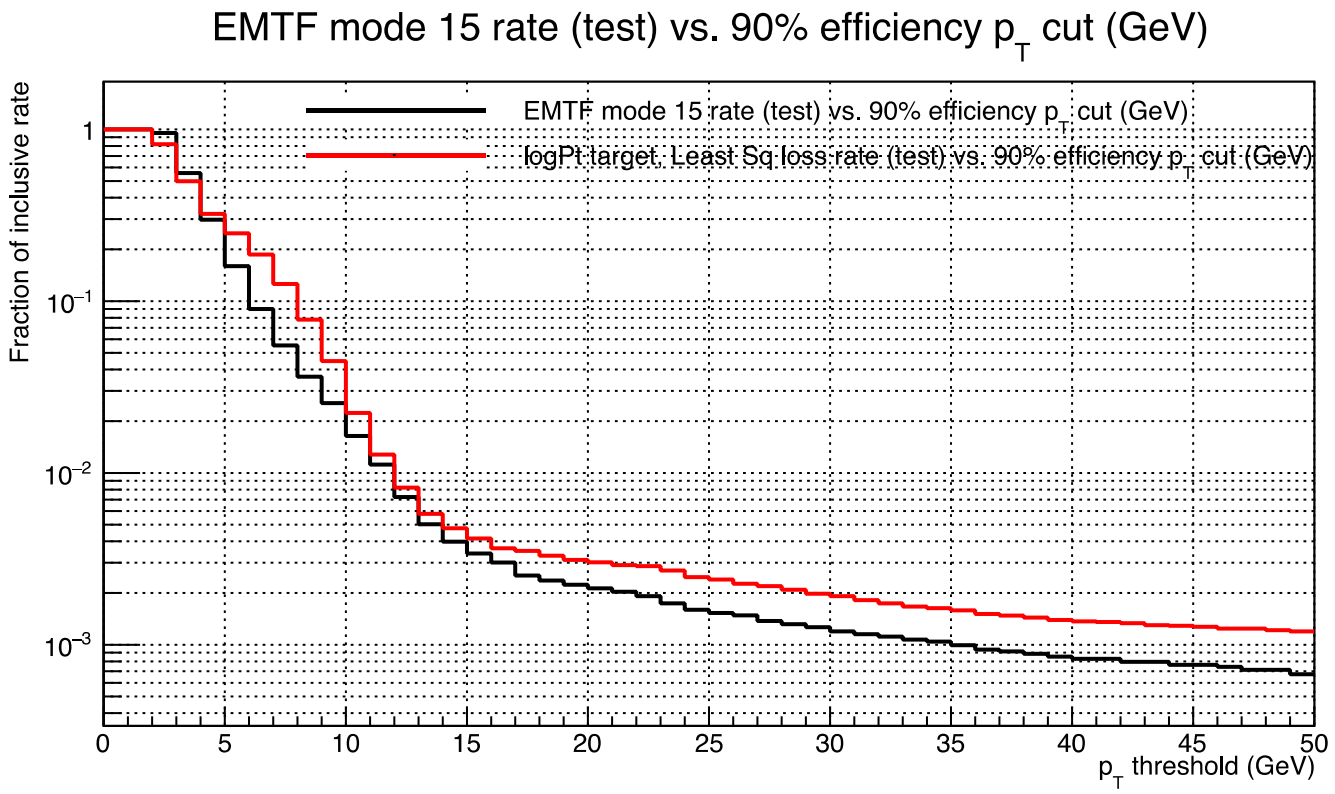
Efficiency @ 16GeV



Efficiency @ 24GeV



Rate

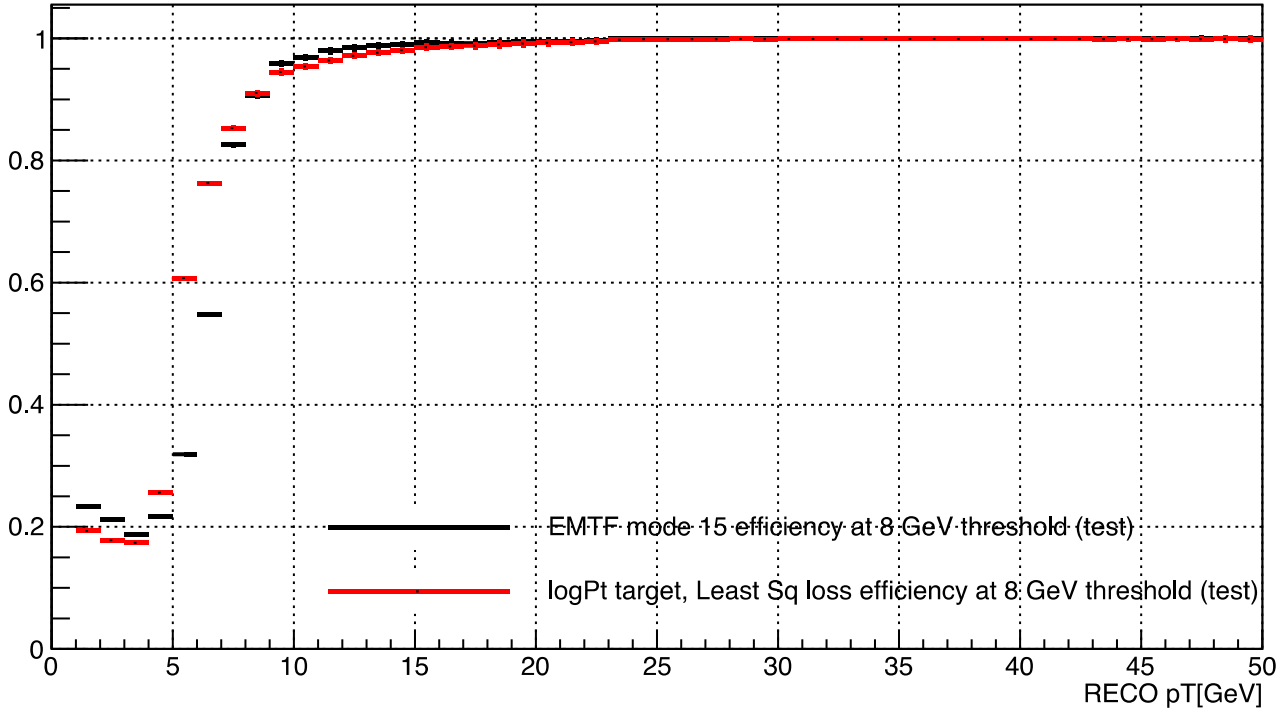

EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
logPt target, Least Sq loss rate (test) vs. 90% efficiency p_T cut (GeV)
Fraction of inclusive rate
1
10^-1
10^-2
10^-3
0
5
10
15
20
25
30
35
40
45
50
p_T threshold (GeV)

Basics

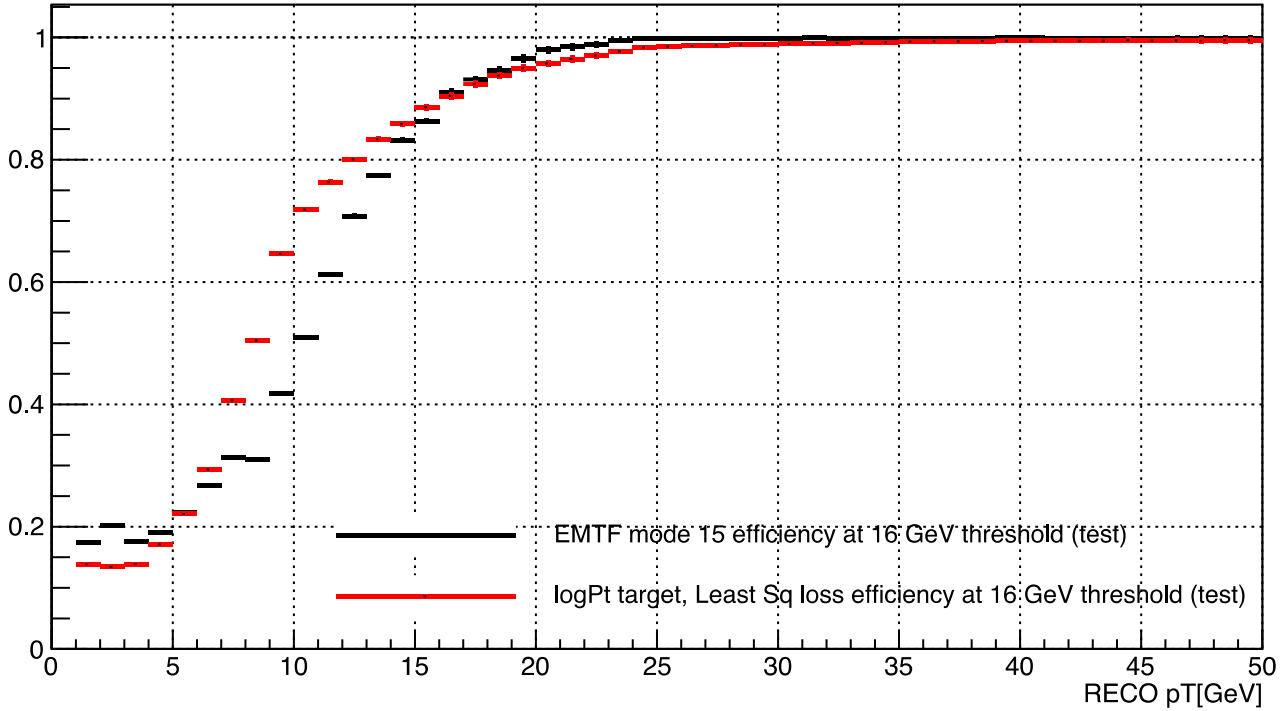
- Train 85,265 muons
  - SingleMu data
  - EMTF track uniquely matched to RECO muon
  - Removed bias in SingleMu data [1]
    - Removed events with only 1 EMTF muon in endcap [2]
- Test 7,017,799 muons
  - SingleMu data (uniquely matched) + ZeroBias
- Settings
  - logPt target, 1/pT weight, Least Square loss function
  - Other BDT parameters same to 2017 BDT setting

[1] Slide 6, https://twiki.cern.ch/twiki/pub/CMS/EMTFAnalyzer/EMTF_Studies_on_Reco_Muons.pdf
[2] https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C#L412-L432

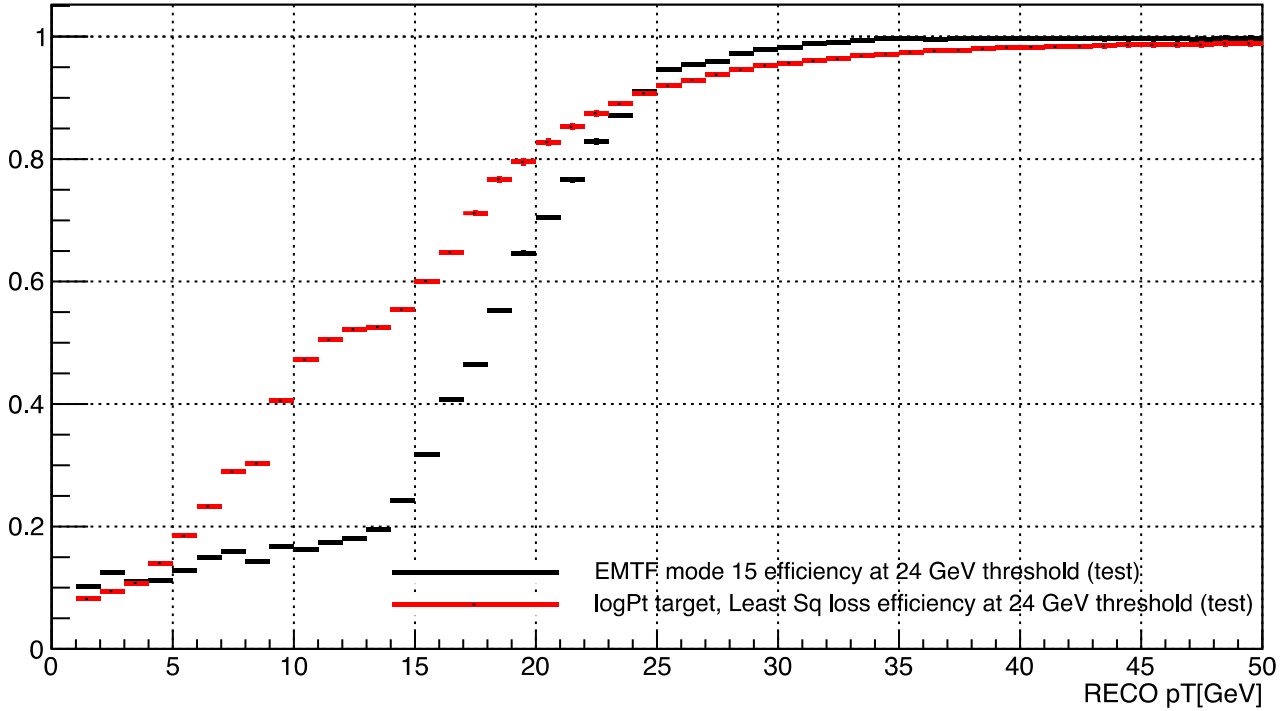
Efficiency @ 8GeV



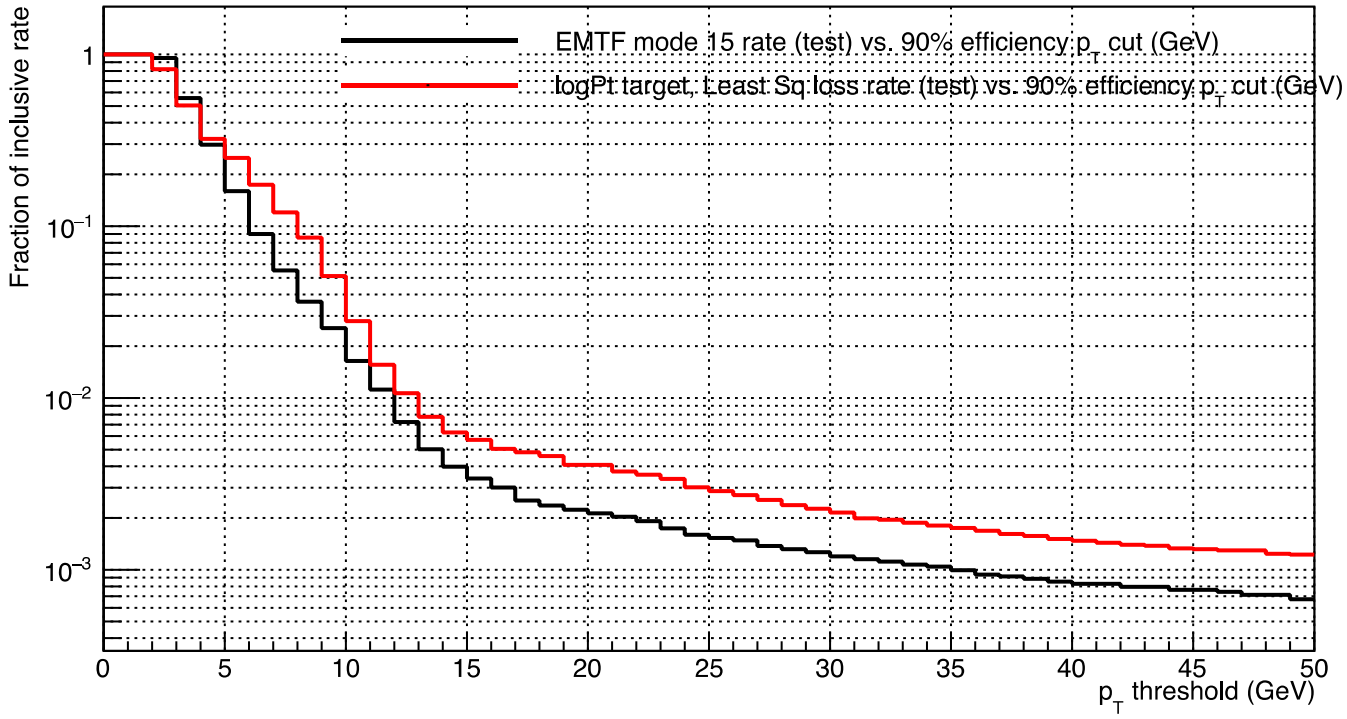
Efficiency @ 16GeV



Efficiency @ 24GeV



Rate

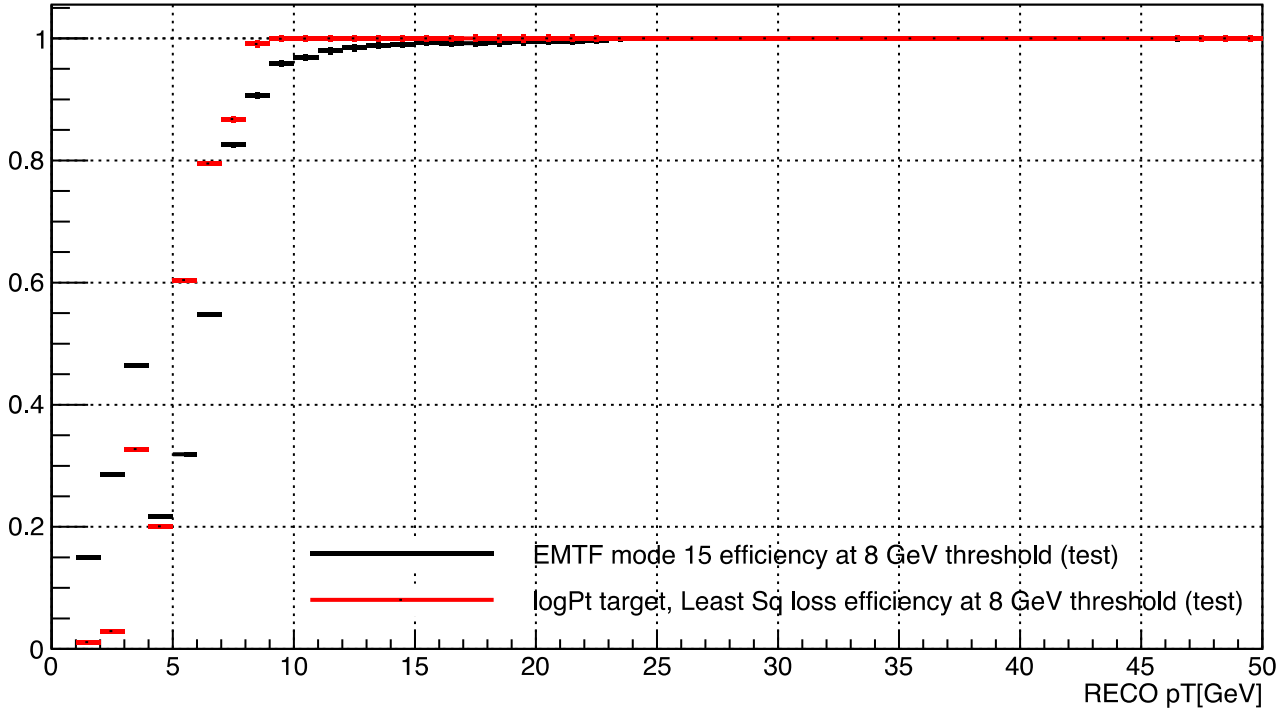

EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
logPt target, Least Sq loss rate (test) vs. 90% efficiency p_T cut (GeV)
Fraction of inclusive rate
1
10^-1
10^-2
10^-3
0
5
10
15
20
25
30
35
40
45
50
p_T threshold (GeV)

Basics

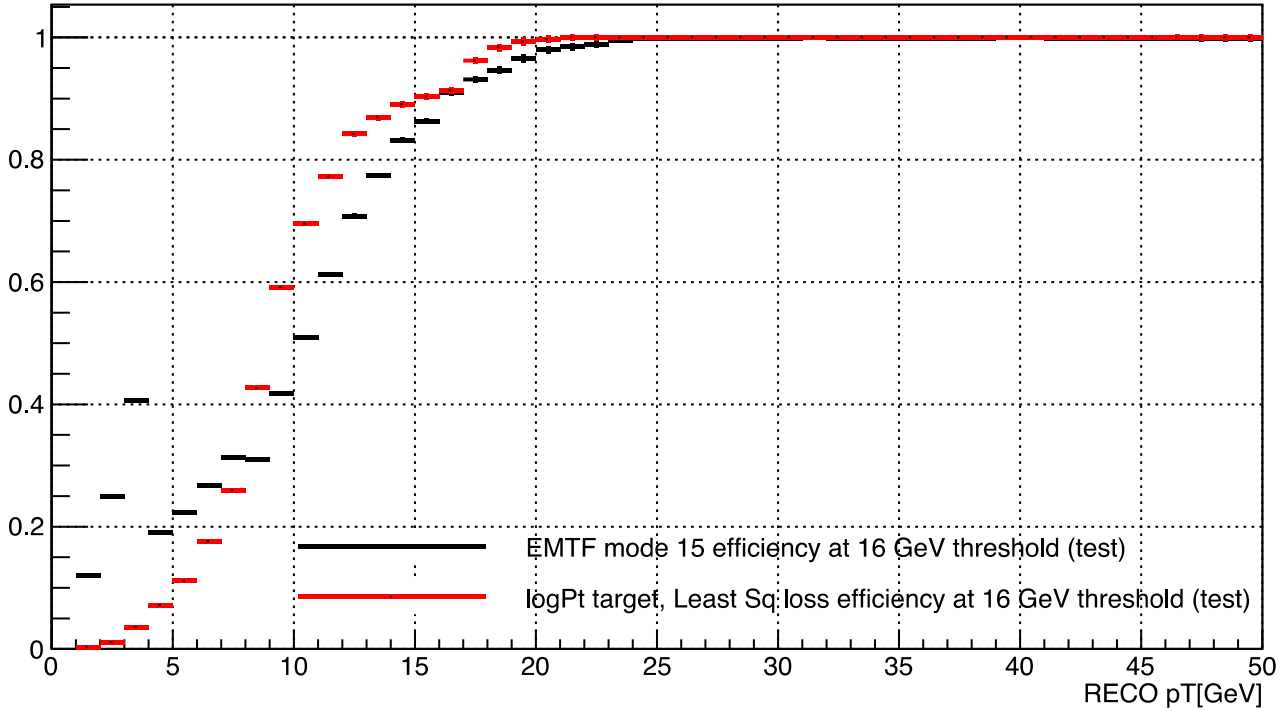
- Train 249,290 muons
  - SingleMu data
  - EMTF track uniquely matched to RECO muon + Not Uniquely matched (assign uGMT default pT to RECO muon)
  - Removed bias in SingleMu data [1]
    - Removed events with only 1 EMTF muon in endcap [2]
- Test 10,670,100 muons
  - SingleMu data + ZeroBias
- Settings
  - logPt target, 1/pT weight, Least Square loss function
  - Other BDT parameters same to 2017 BDT setting

[1] Slide 6, https://twiki.cern.ch/twiki/pub/CMS/EMTFAnalyzer/EMTF_Studies_on_Reco_Muons.pdf
[2] https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C#L412-L432

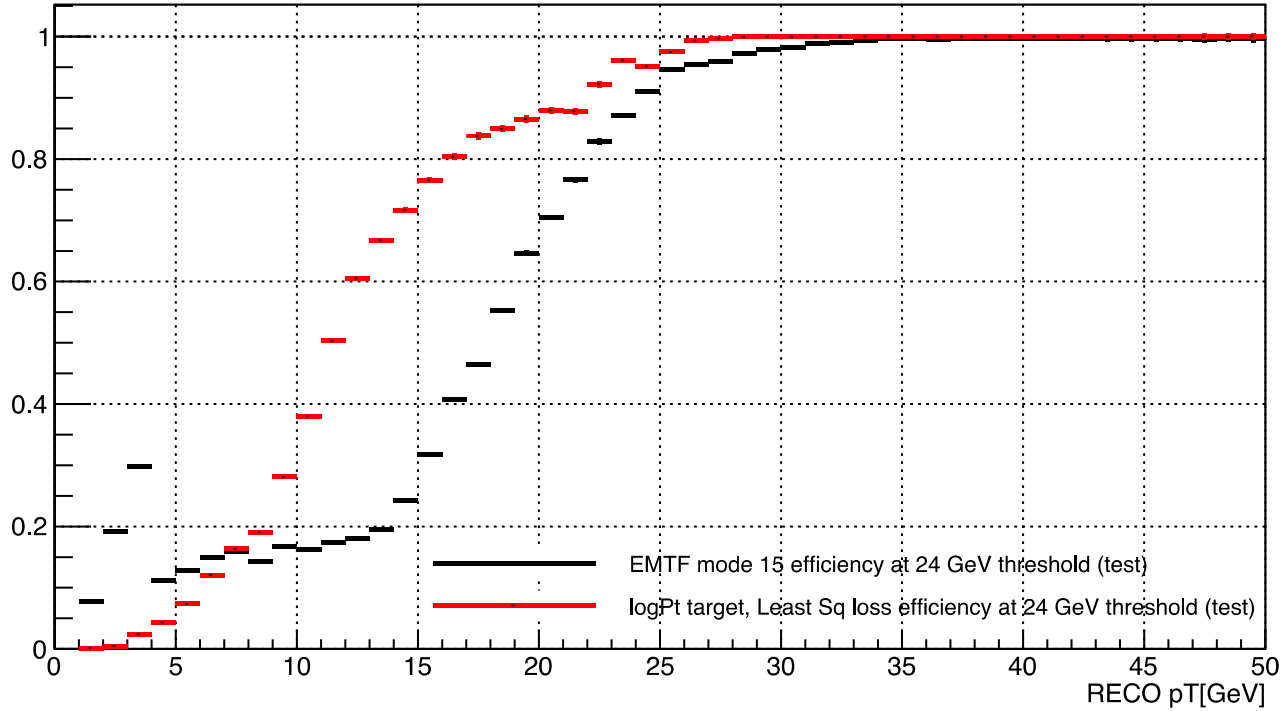
Efficiency @ 8GeV



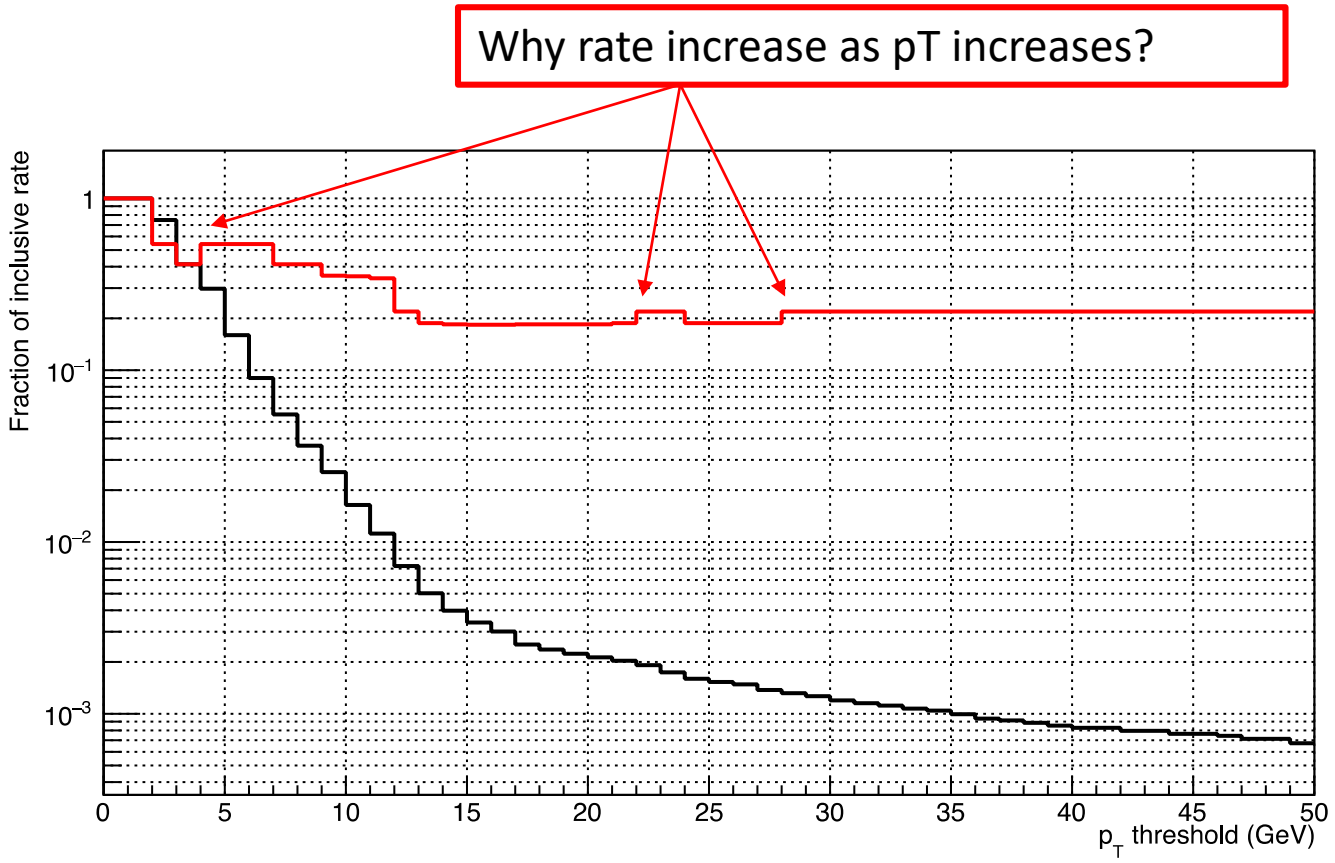
Efficiency @ 16GeV



Efficiency @ 24GeV

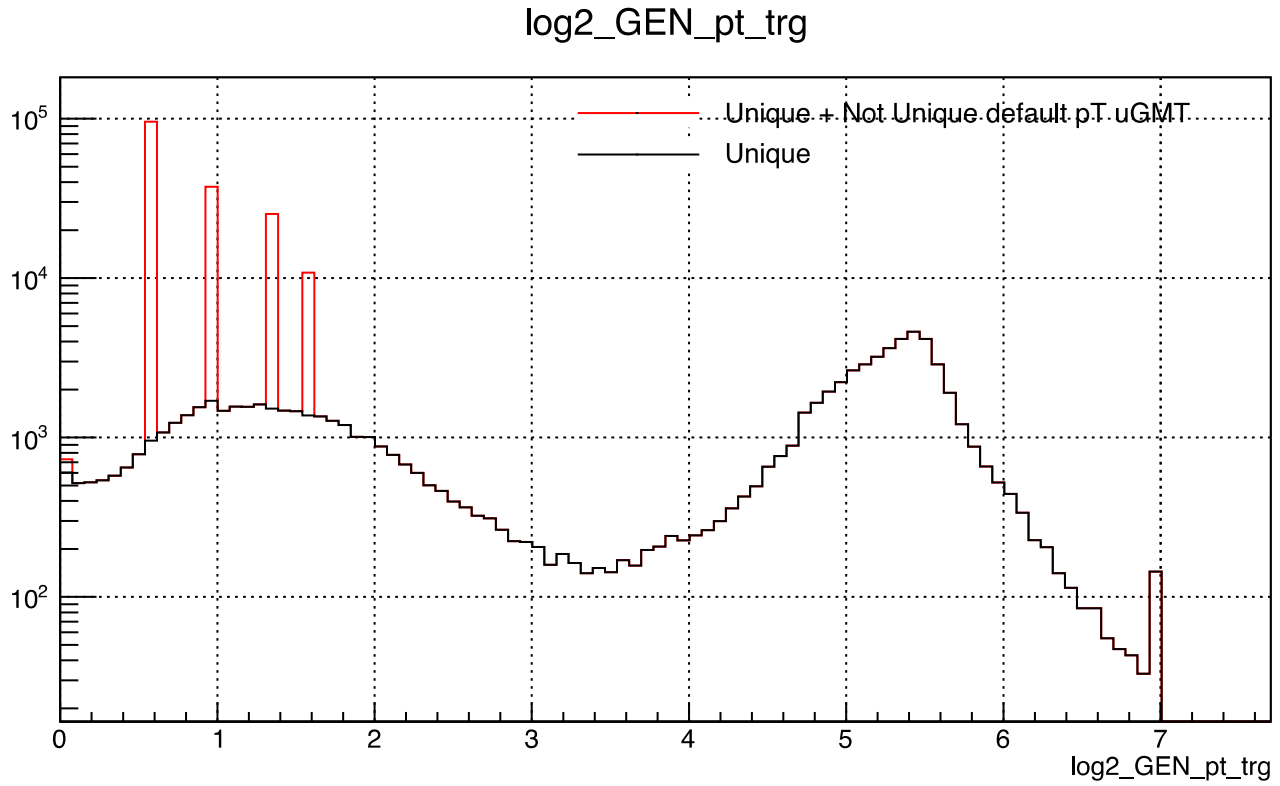


Rate


Why rate increase as pT increases?
Fraction of inclusive rate
1
10^{-1}
10^{-2}
10^{-3}
0
5
10
15
20
25
30
35
40
45
50
p_T threshold (GeV)

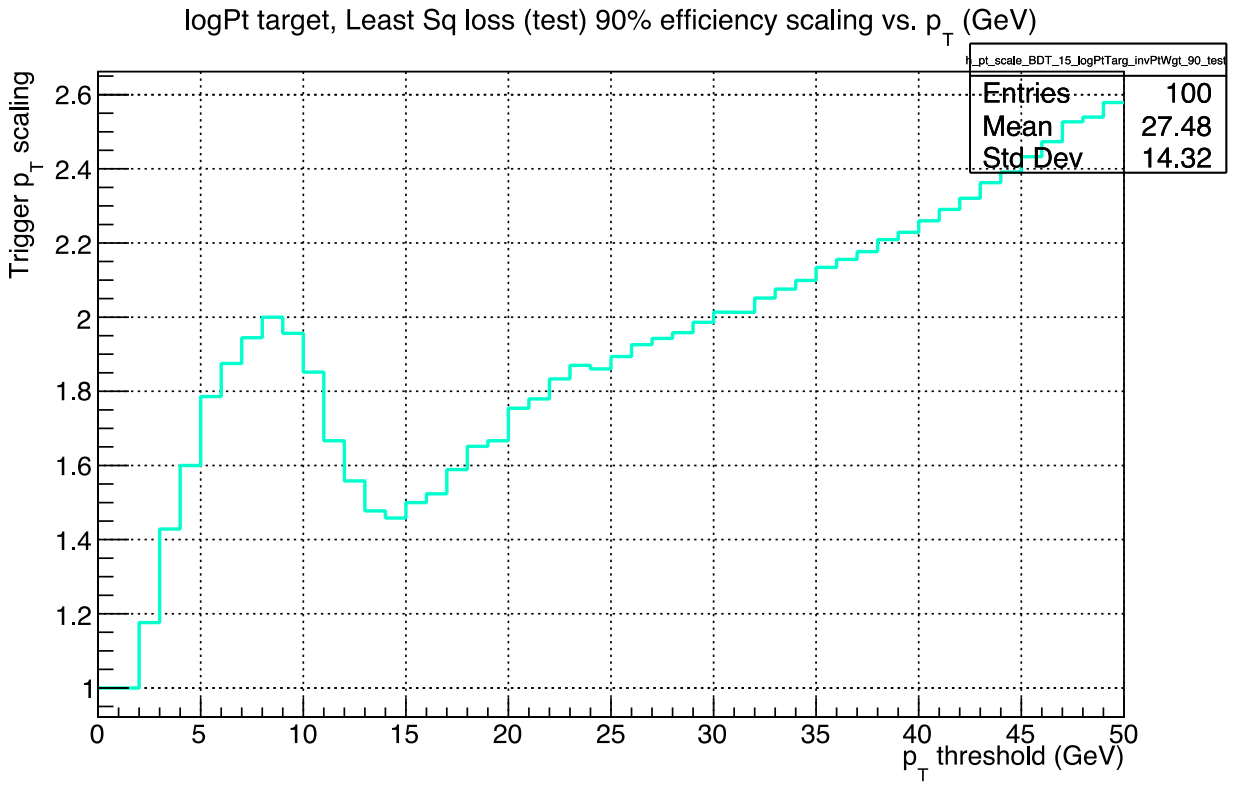
Compare Target

- Current default pT setting for not uniquely matched tracks (from uGMT [1-2])
  - mu_eta = emtf_eta_int∗0.010875;
  - gmt_pt = 10 - (abs(emtf_eta_int) / 32);
  - mu_pt = (gmt_pt <= 0) ? 0 : (gmt_pt-1) * 0.5;
- Four discrete peaks at low pT
  - Due to emtf_eta_int is “int” type

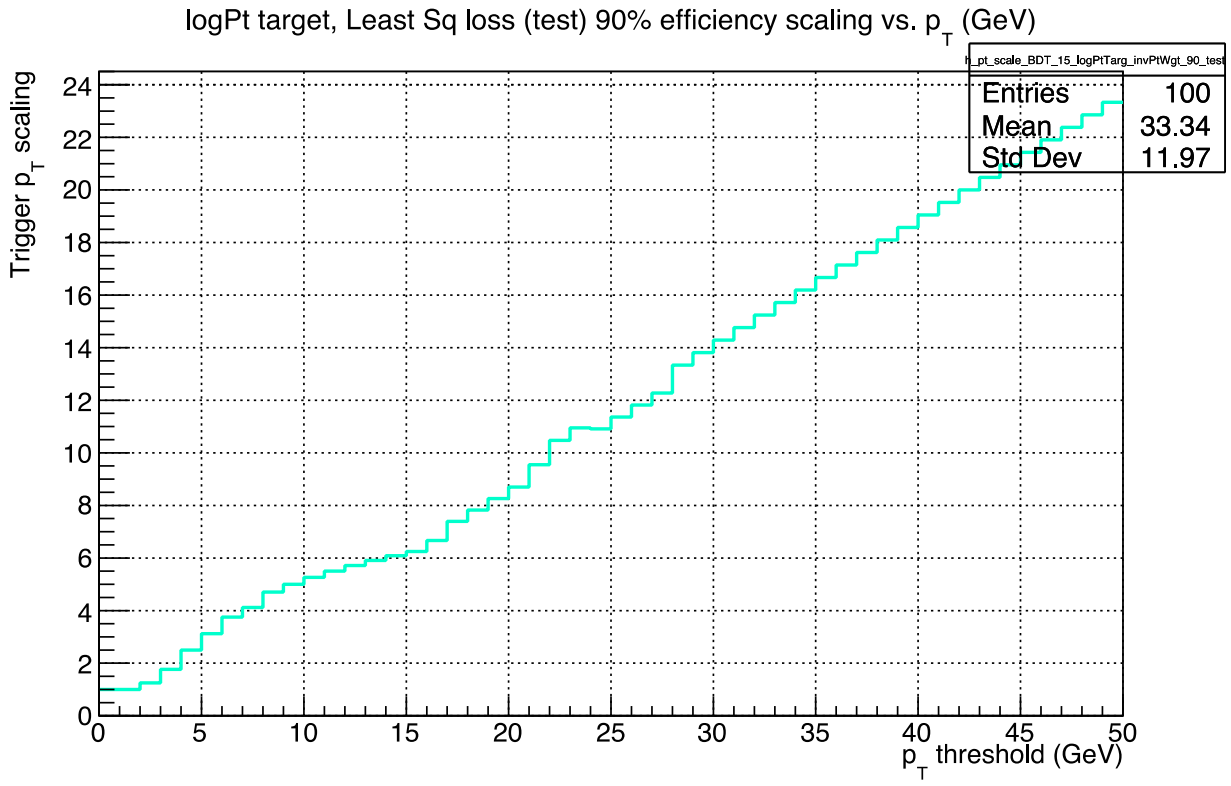


[1] https://github.com/cms-sw/cmssw/blob/master/L1Trigger/L1TMuonEndCap/src/PtAssignment.cc#L86-L89
[2] https://github.com/cms-sw/cmssw/blob/master/L1Trigger/L1TMuonEndCap/interface/TrackTools.h#L77-L81

Compare pT Scale

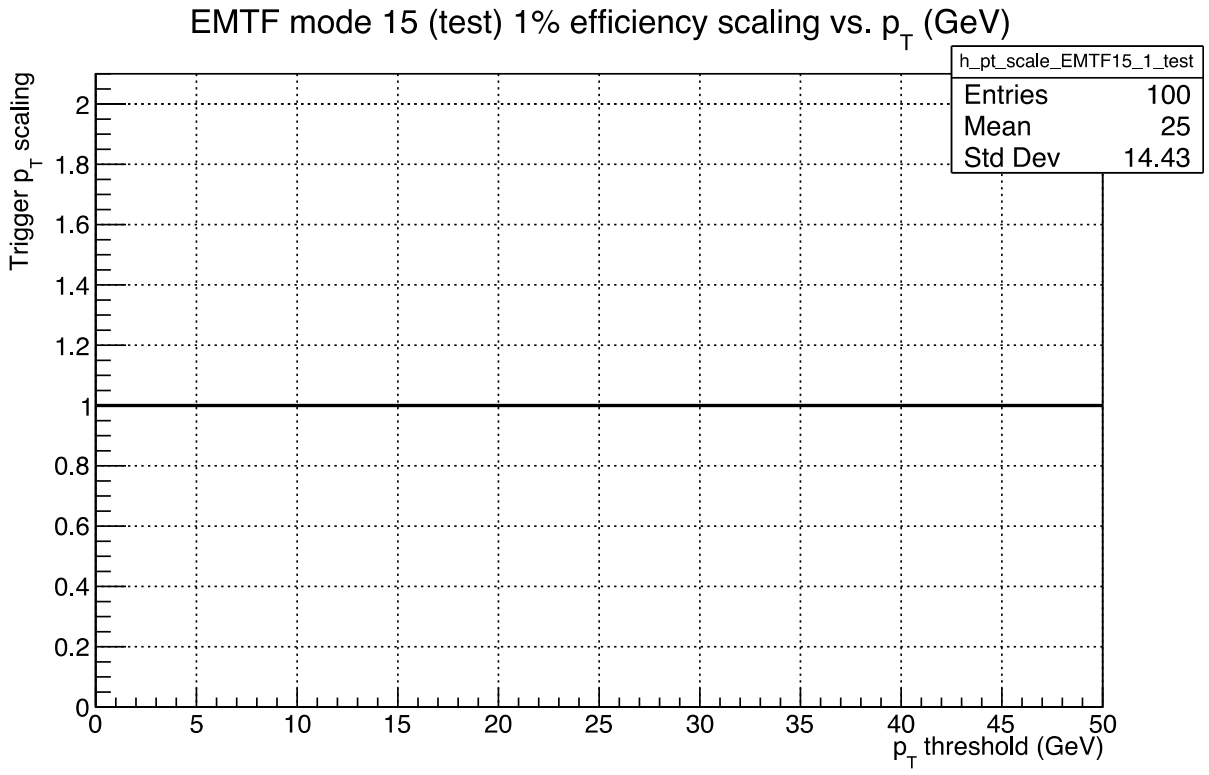


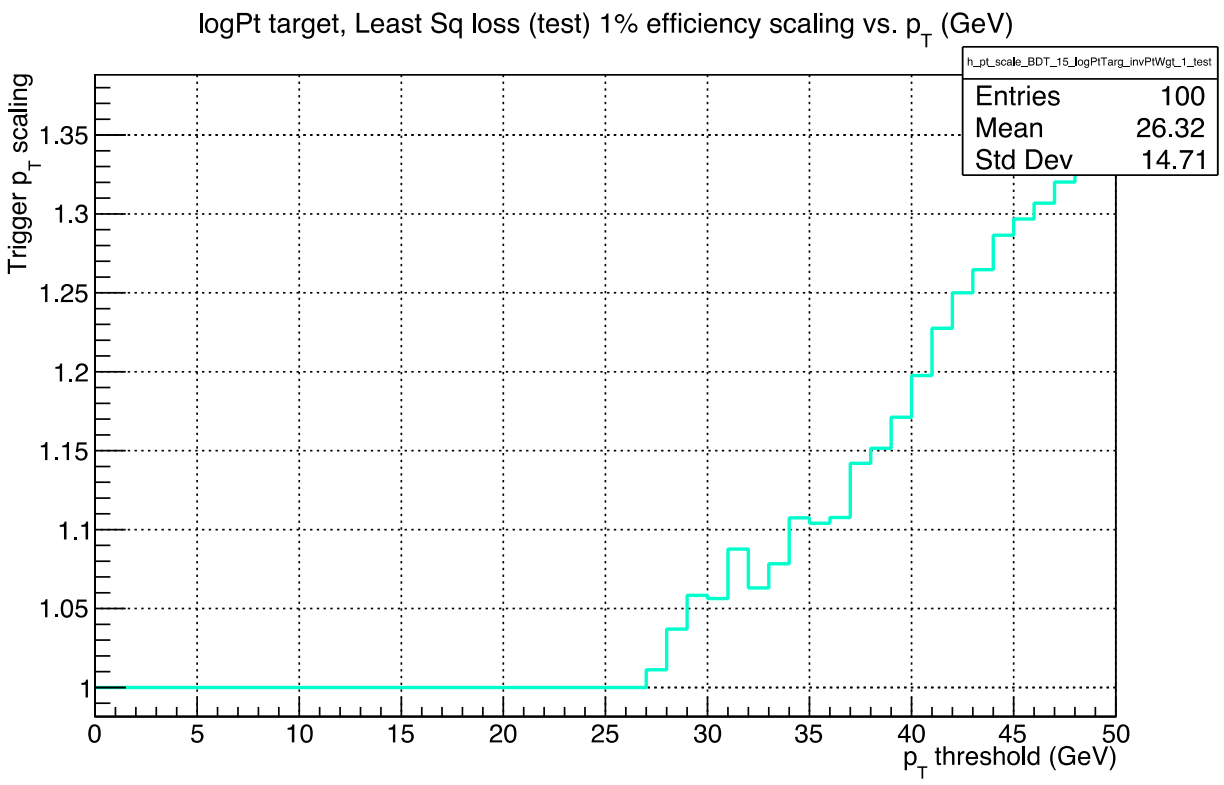
Uniquely matched Only



Include not uniquely matched

pT Scale @1% efficiency





EMTF

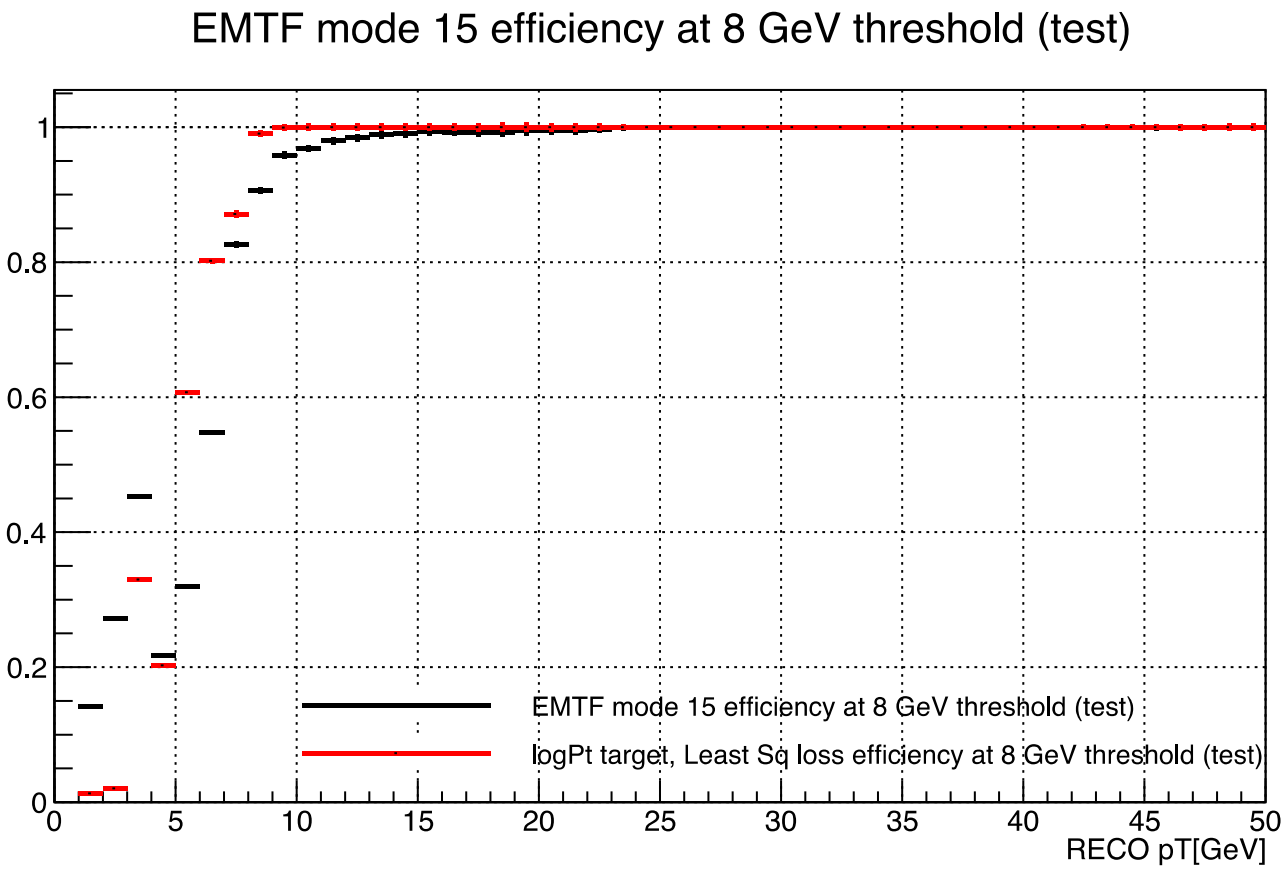
New BDT: Include not uniquely matched

Basics

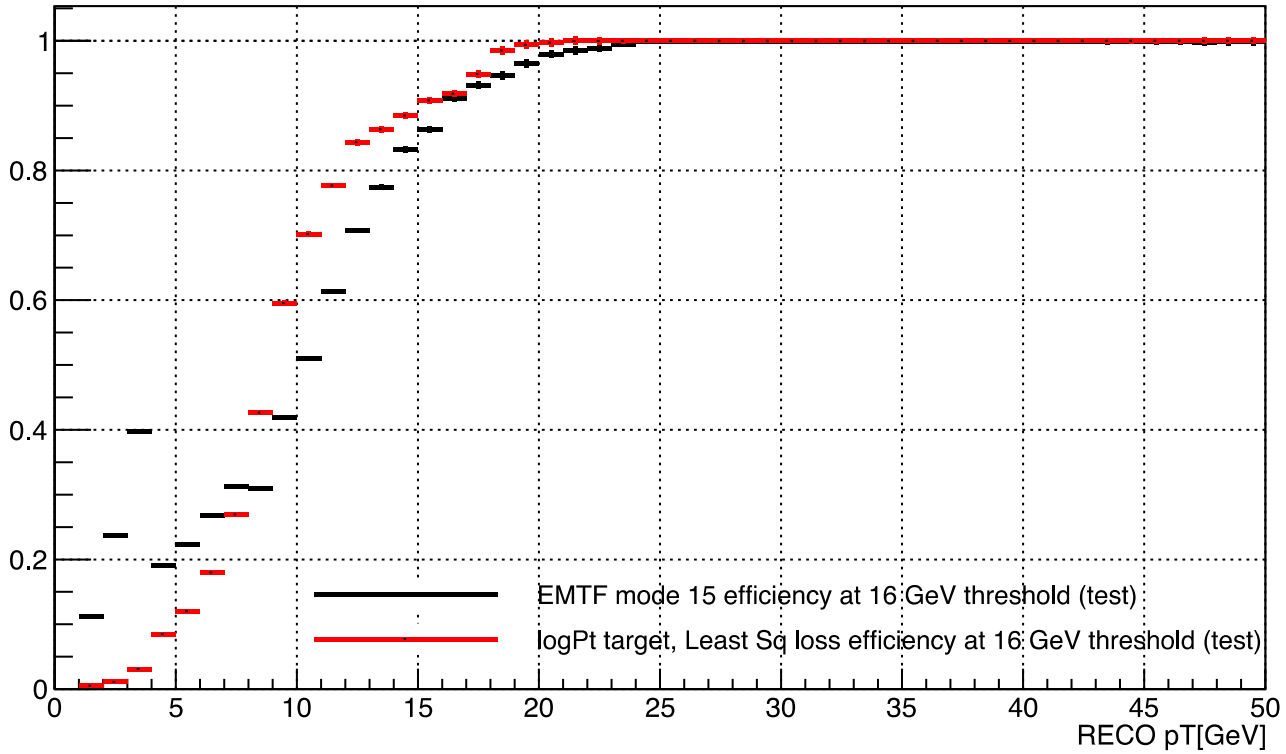
- Train 246,738 muons
  - SingleMu data
  - EMTF track uniquely matched to RECO muon + No RECO match (assign uGMT default pT to RECO muon)
  - Removed bias in SingleMu data [1]
    - Removed events with only 1 EMTF muon in endcap [2]
- Test 10,549,360 muons
  - SingleMu data + ZeroBias
- Settings
  - logPt target, 1/pT weight, Least Square loss function
  - Other BDT parameters same to 2017 BDT setting

[1] Slide 6, https://twiki.cern.ch/twiki/pub/CMS/EMTFAnalyzer/EMTF_Studies_on_Reco_Muons.pdf
[2] https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C#L412-L432

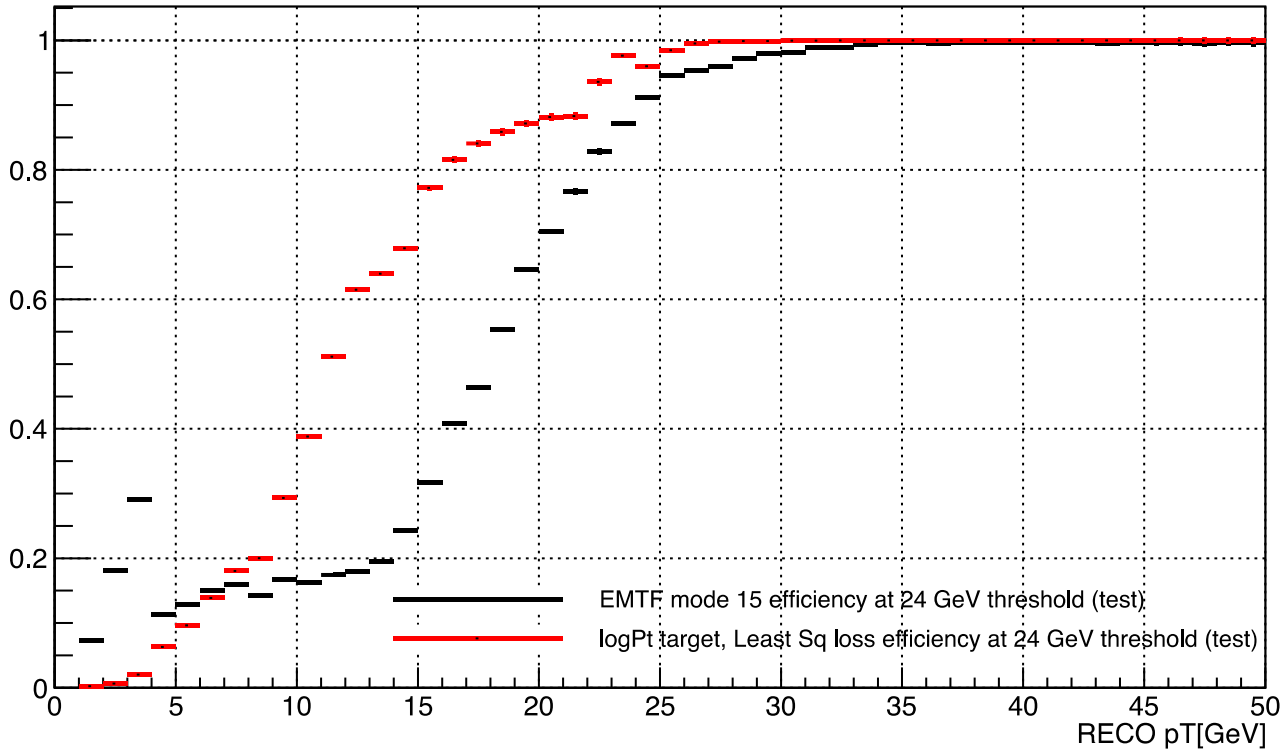
Efficiency @ 8GeV



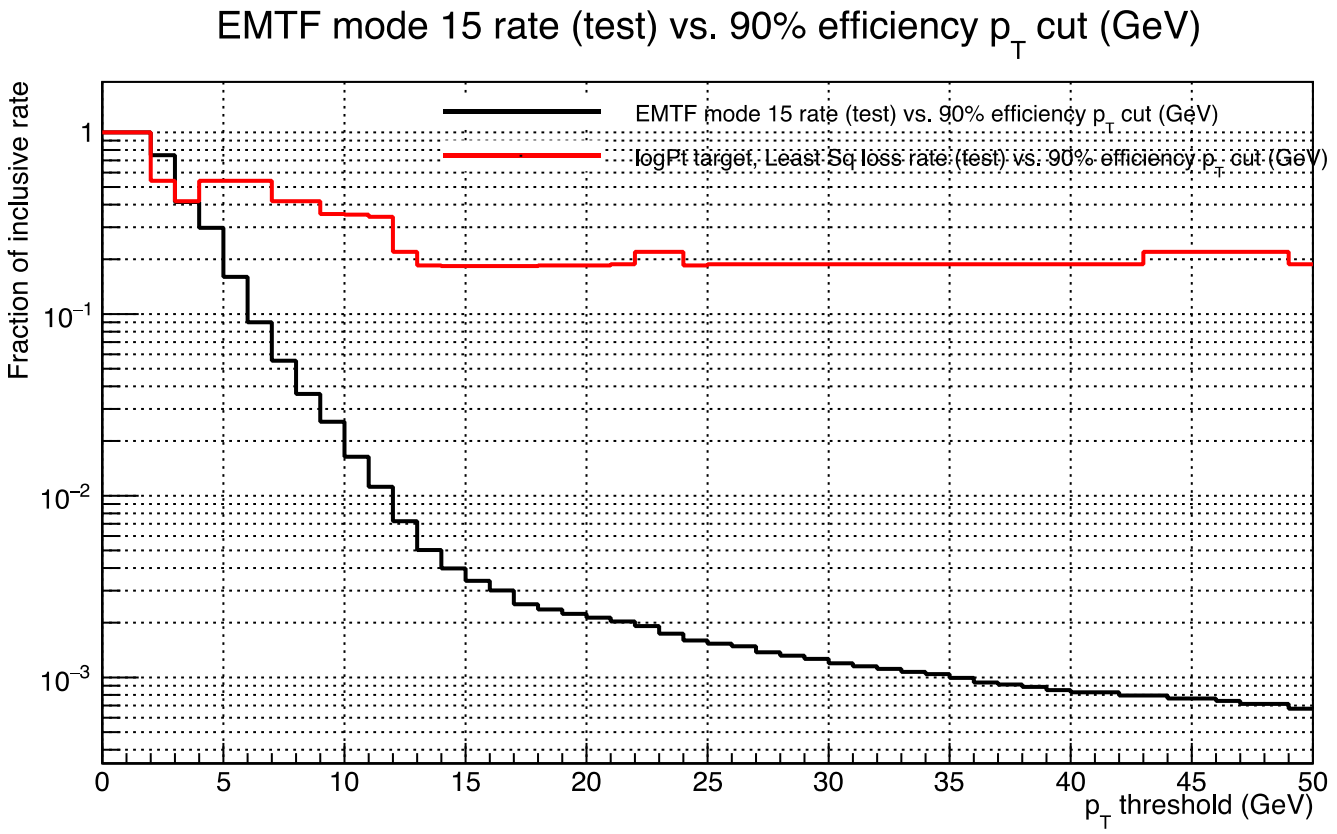
Efficiency @ 16GeV



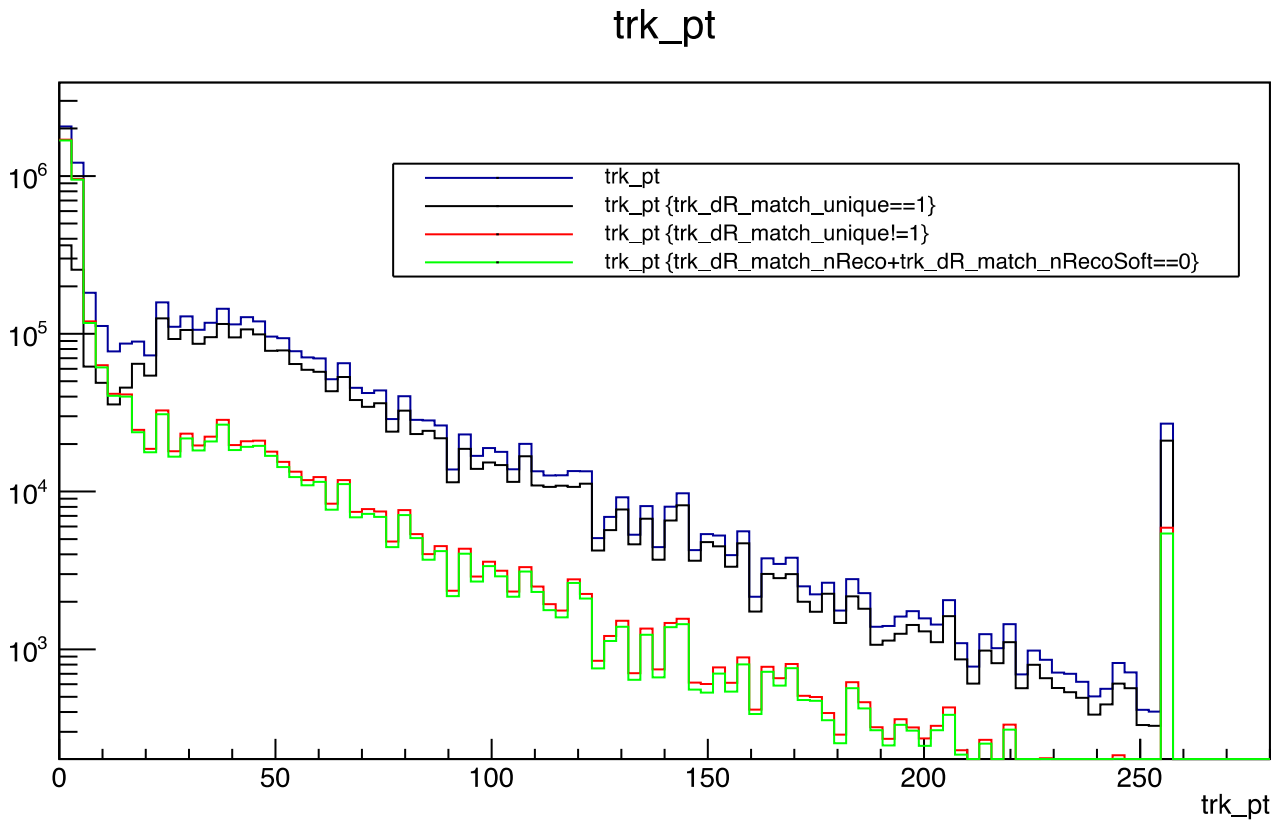
Efficiency @ 24GeV



Rate


EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
logPt target, Least Sq loss rate (test) vs. 90% efficiency p_T cut (GeV)
Fraction of inclusive rate
1
10^{-1}
10^{-2}
10^{-3}
0
5
10
15
20
25
30
35
40
45
50
p_T threshold (GeV)

Trk_pT from one SingleMu file



Back Up

Additional Info

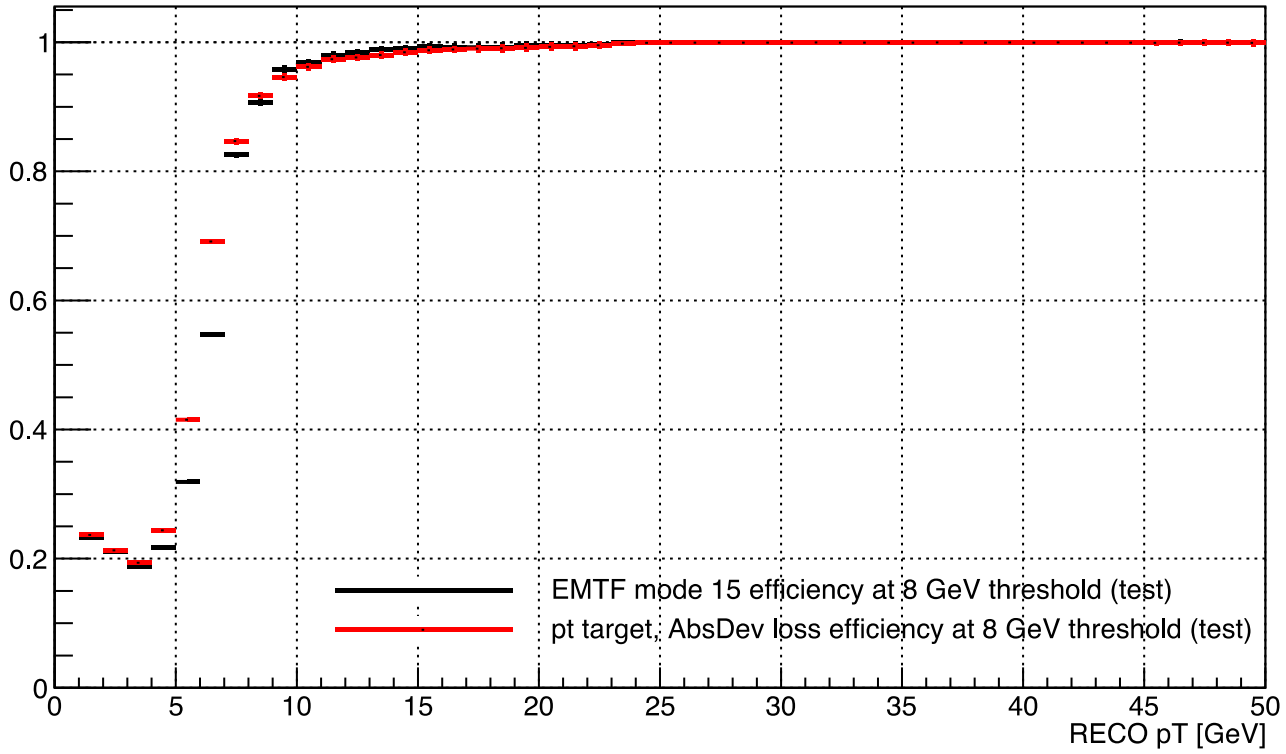
- Output Files
  - /eos/user/w/wshi/2018PtTraining
- Training macro
  - https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C
- RateVsEff macro
  - https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/macros/RateVsEff.C

Basics

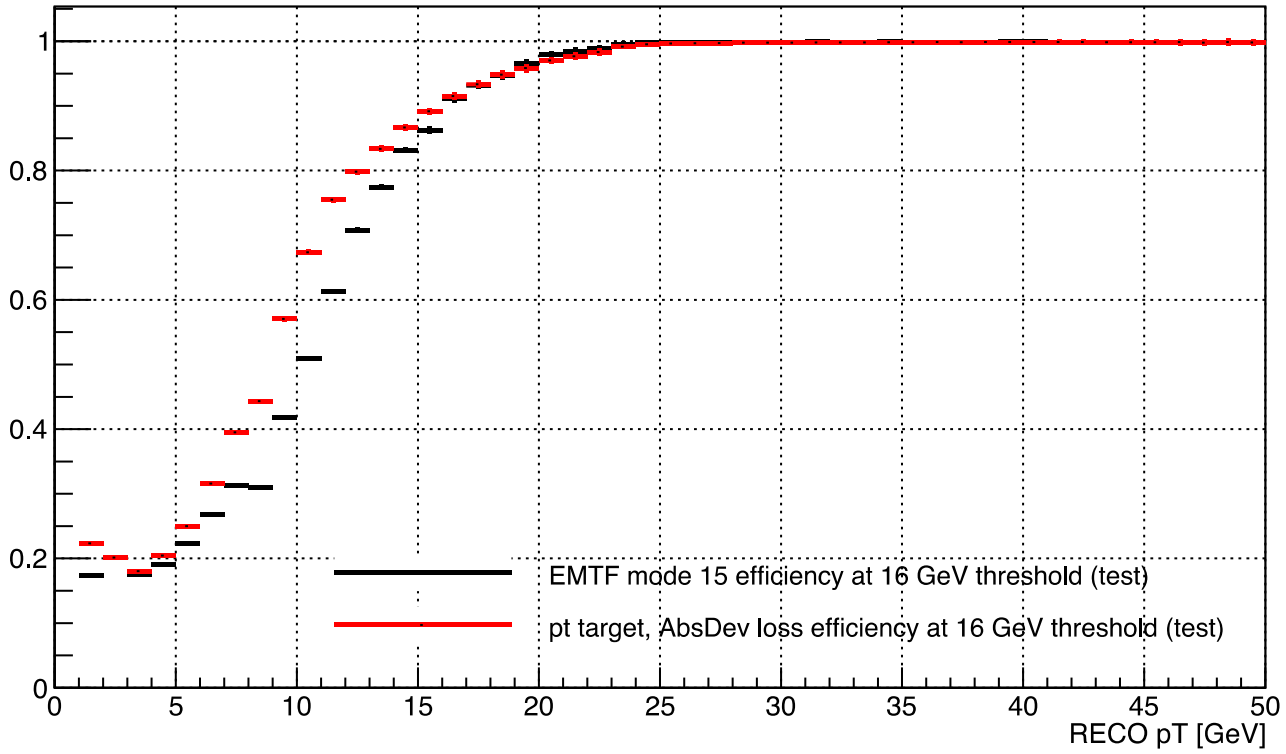
- Train 85,265 muons
  - SingleMu data
  - EMTF track uniquely matched to RECO muon
  - Removed bias in SingleMu data [1]
    - Removed events with only 1 EMTF muon in endcap [2]
- Test 7,017,799 muons
  - SingleMu data (uniquely matched) + ZeroBias
- Settings
  - pT target, no weight, Absolute deviation loss function
  - Other BDT parameters same to 2017 BDT setting

[1] Slide 6, https://twiki.cern.ch/twiki/pub/CMS/EMTFAnalyzer/EMTF_Studies_on_Reco_Muons.pdf
[2] https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C#L412-L432

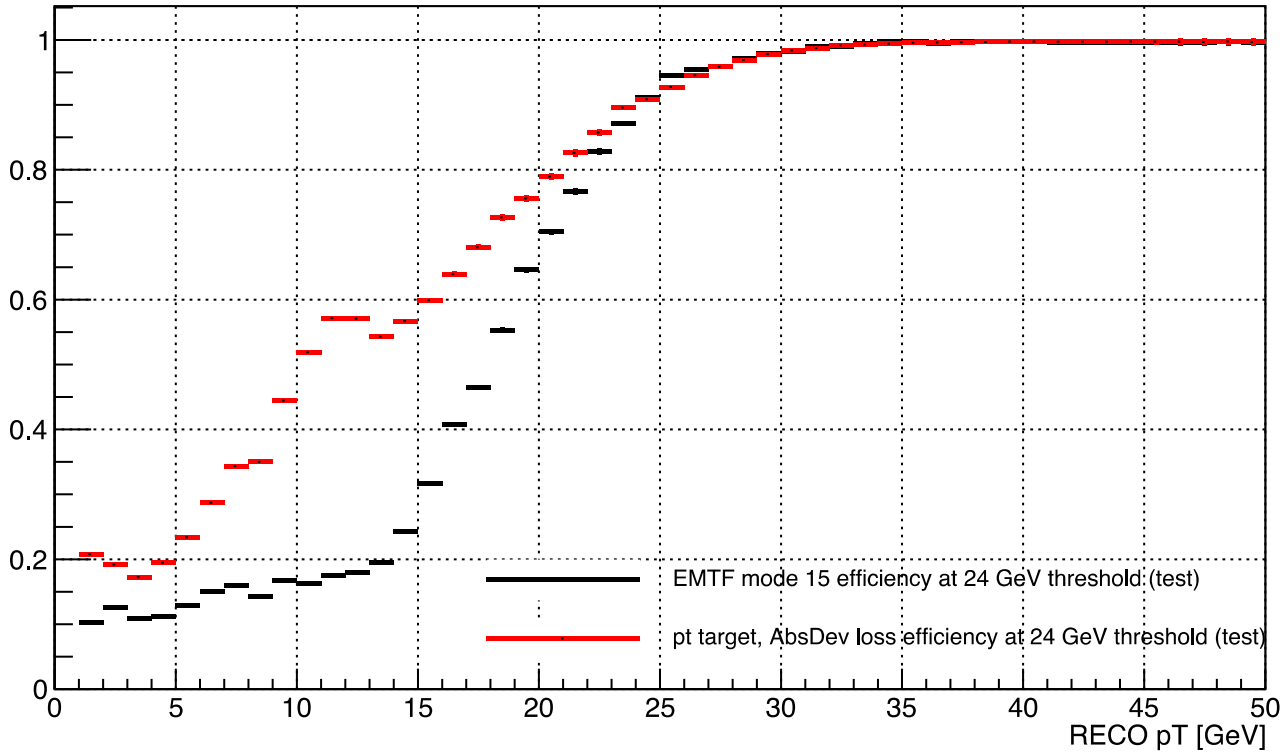
Efficiency @ 8GeV



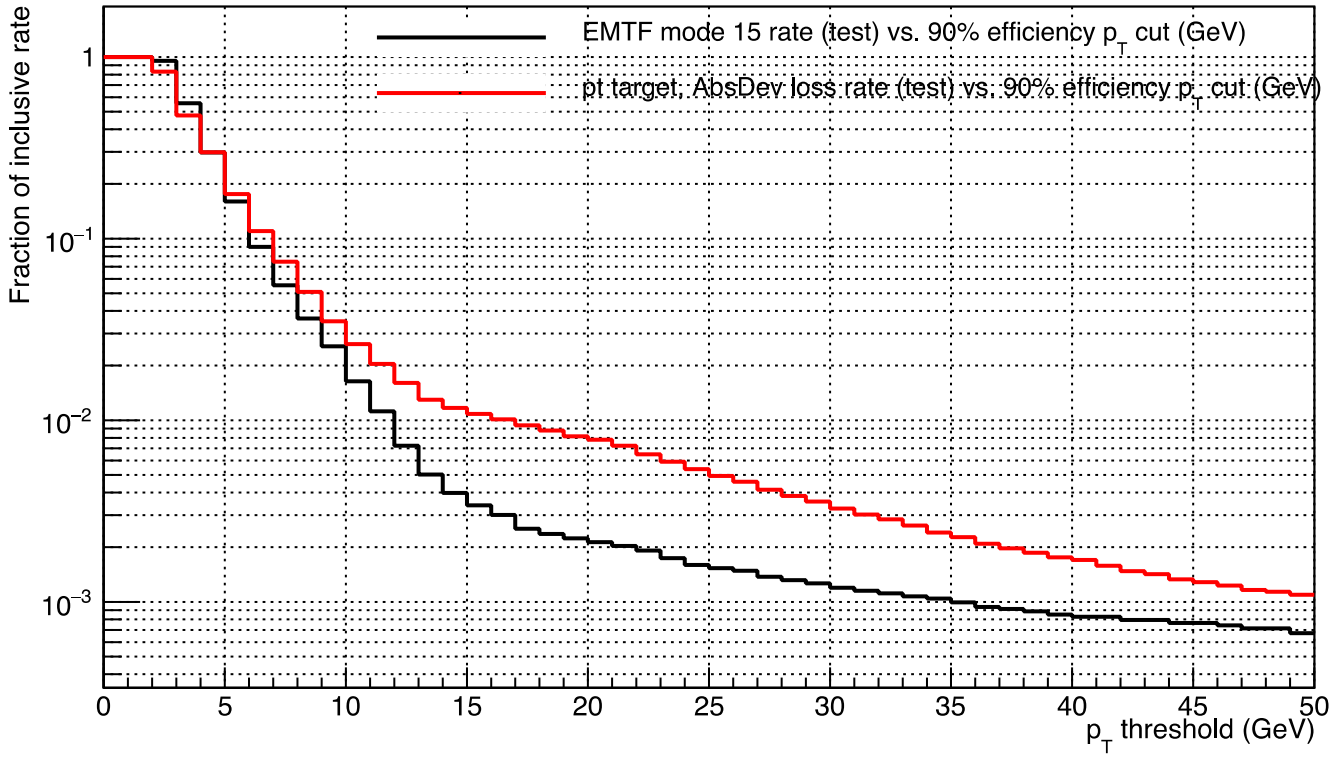
Efficiency @ 16GeV



Efficiency @ 24GeV



Rate


EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
pt target, AbsDev loss rate (test) vs. 90% efficiency p_T cut (GeV)
Fraction of inclusive rate
1
10^{-1}
10^{-2}
10^{-3}
0
5
10
15
20
25
30
35
40
45
50
p_T threshold (GeV)

Back Up

Some Useful info from TMVA

Correlation matrix (Regression):

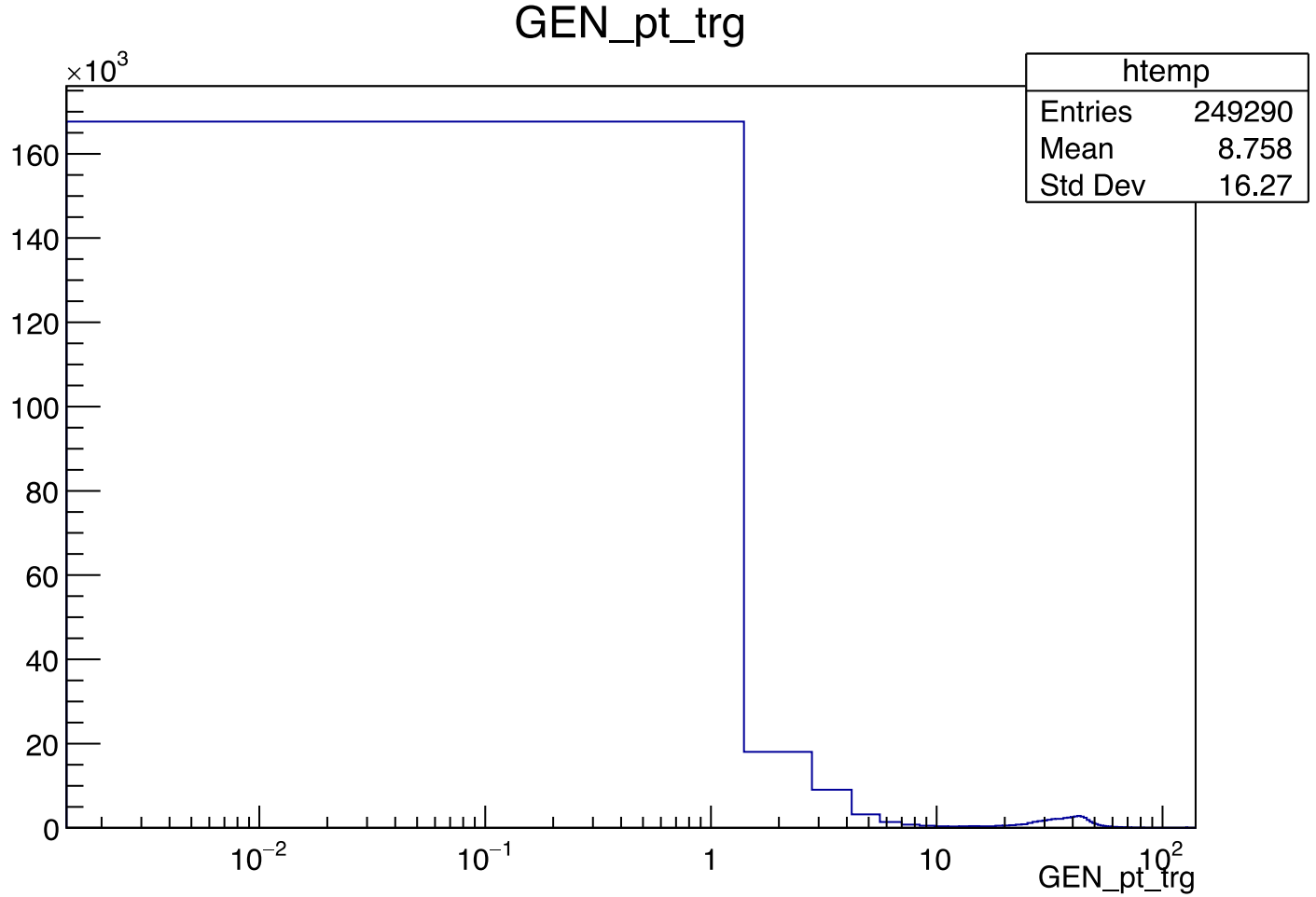
	theta	St1_ring2	dPhi_12	dPhi_23	dPhi_34	dPhi_13	dPhi_14	dPhi_24	FR_1	bend_1	dPhiSum4	dPhiSum4A	dPhiSum3	dPhiSum3A	outStPhi	dTh_14
theta:	+1.000	+0.934	-0.460	-0.117	+0.157	-0.457	-0.431	+0.030	+0.033	-0.150	-0.420	-0.464	-0.001	-0.364	+0.010	+0.140
St1_ring2:	+0.934	+1.000	-0.442	-0.092	+0.144	-0.434	-0.411	+0.035	+0.014	-0.128	-0.399	-0.433	+0.028	-0.324	+0.034	+0.132
dPhi_12:	-0.460	-0.442	+1.000	+0.161	-0.436	+0.970	+0.888	-0.172	+0.030	+0.644	+0.859	+0.980	-0.147	+0.731	-0.107	-0.487
dPhi_23:	-0.117	-0.092	+0.161	+1.000	+0.531	+0.395	+0.559	+0.863	-0.005	-0.072	+0.613	+0.203	+0.595	-0.183	-0.324	+0.132
dPhi_34:	+0.157	+0.144	-0.436	+0.531	+1.000	-0.275	-0.008	+0.886	+0.018	-0.474	+0.036	-0.416	+0.632	-0.649	-0.236	+0.413
dPhi_13:	-0.457	-0.434	+0.970	+0.395	-0.275	+1.000	+0.963	+0.051	+0.027	+0.582	+0.950	+0.962	+0.009	+0.635	-0.179	-0.421
dPhi_14:	-0.431	-0.411	+0.888	+0.559	-0.008	+0.963	+1.000	+0.300	+0.033	+0.473	+0.998	+0.885	+0.186	+0.480	-0.252	-0.322
dPhi_24:	+0.030	+0.035	-0.172	+0.863	+0.886	+0.051	+0.300	+1.000	+0.008	-0.322	+0.356	-0.137	+0.702	-0.487	-0.318	+0.319
FR_1:	+0.033	+0.014	+0.030	-0.005	+0.018	+0.027	+0.033	+0.008	+1.000	-0.024	+0.031	+0.018	-0.019	-0.016	-0.044	-0.024
bend_1:	-0.150	-0.128	+0.644	-0.072	-0.474	+0.582	+0.473	-0.322	-0.024	+1.000	+0.445	+0.642	-0.208	+0.572	+0.061	-0.484
dPhiSum4:	-0.420	-0.399	+0.859	+0.613	+0.036	+0.950	+0.998	+0.356	+0.031	+0.445	+1.000	+0.859	+0.225	+0.442	-0.267	-0.296
dPhiSum4A:	-0.464	-0.433	+0.980	+0.203	-0.416	+0.962	+0.885	-0.137	+0.018	+0.642	+0.859	+1.000	-0.044	+0.785	-0.034	-0.486
dPhiSum3:	-0.001	+0.028	-0.147	+0.595	+0.632	+0.009	+0.186	+0.702	-0.019	-0.208	+0.225	-0.044	+1.000	-0.227	+0.029	+0.211
dPhiSum3A:	-0.364	-0.324	+0.731	-0.183	-0.649	+0.635	+0.480	-0.487	-0.016	+0.572	+0.442	+0.785	-0.227	+1.000	+0.135	-0.467
outStPhi:	+0.010	+0.034	-0.107	-0.324	-0.236	-0.179	-0.252	-0.318	-0.044	+0.061	-0.267	-0.034	+0.029	+0.135	+1.000	-0.097
dTh_14:	+0.140	+0.132	-0.487	+0.132	+0.413	-0.421	-0.322	+0.319	-0.024	-0.484	-0.296	-0.486	+0.211	-0.467	-0.097	+1.000

Some Useful info from TMVA

```
Ranking input variables (method unspecific)...
Ranking result (top variable is best ranked)
----------------------------------------------
Rank : Variable  : |Correlation with target|
----------------------------------------------
   1 : dPhiSum4A : 7.199e-01
   2 : dPhi_12   : 7.035e-01
   3 : dPhi_13   : 6.559e-01
   4 : dPhiSum3A : 6.373e-01
   5 : bend_1    : 5.951e-01
   6 : dPhi_14   : 5.642e-01
   7 : dPhiSum4  : 5.378e-01
   8 : dTh_14    : 4.479e-01
   9 : dPhi_34   : 4.234e-01
  10 : theta     : 3.526e-01
  11 : St1_ring2 : 3.009e-01
  12 : dPhi_24   : 2.501e-01
  13 : dPhiSum3  : 1.151e-01
  14 : FR_1      : 2.576e-02
  15 : outStPhi  : 2.387e-02
  16 : dPhi_23   : 4.426e-03
```

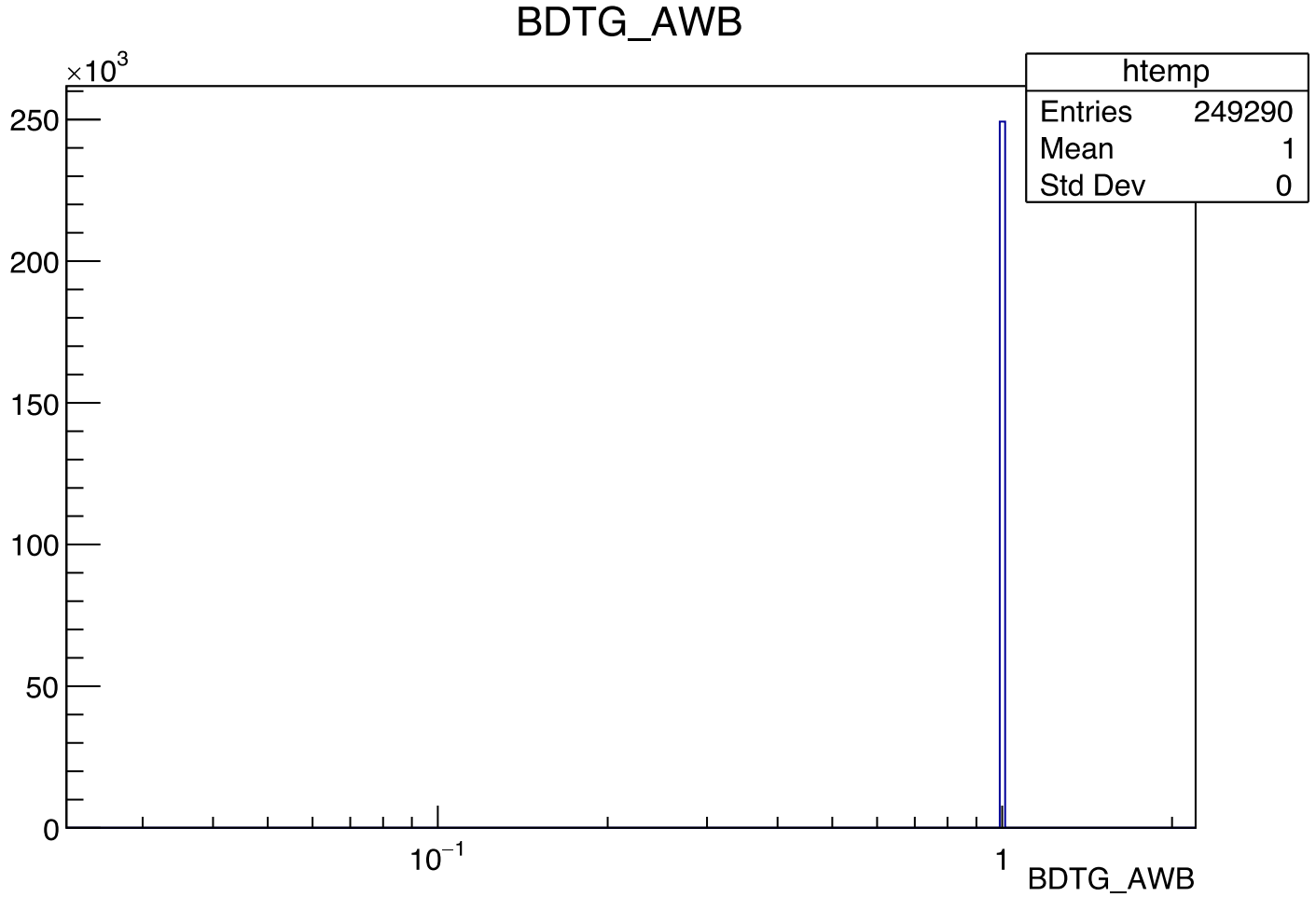
Variable	Mean	RMS	[Min	Max]
theta:	5.0103	4.5058	[0.0000	13.000]
St1_ring2:	0.34822	0.47641	[0.0000	1.0000]
dPhi_12:	106.41	132.85	[0.0000	470.00]
dPhi_23:	2.0012	35.020	[-136.00	136.00]
dPhi_34:	-15.304	38.249	[-136.00	136.00]
dPhi_13:	108.41	142.72	[-135.00	606.00]
dPhi_14:	93.109	137.20	[-232.00	674.00]
dPhi_24:	-13.303	64.121	[-272.00	272.00]
FR_1:	0.49340	0.49996	[0.0000	1.0000]
bend_1:	1.5546	0.70919	[0.0000	3.0000]
dPhiSum4:	281.33	432.15	[-832.00	2158.0]
dPhiSum4A:	393.29	466.04	[0.0000	2158.0]
dPhiSum3:	-3.0195	91.961	[-544.00	544.00]
dPhiSum3A:	66.352	88.117	[0.0000	544.00]
outStPhi:	1.2193	0.73335	[0.0000	4.0000]
dTh_14:	1.6198	0.77743	[0.0000	3.0000]
GEN_pt_trg:	23.681	20.874	[1.0001	128.00]

Include tracks not uniquely matched



- Set RECO pT=1GeV, eta, phi, charge same as EMTF track

Include tracks not uniquely matched



- /eos/user/w/wshi/2018PtTraining/Mode15PtTargNoWgtAbsDevUniquelyMatched_plus_NotUniquelyMatchedRECO1GeV