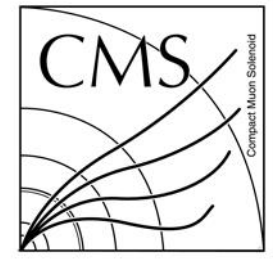# First Results Training pT with Data

Wei Shi

EMTF Working Meeting
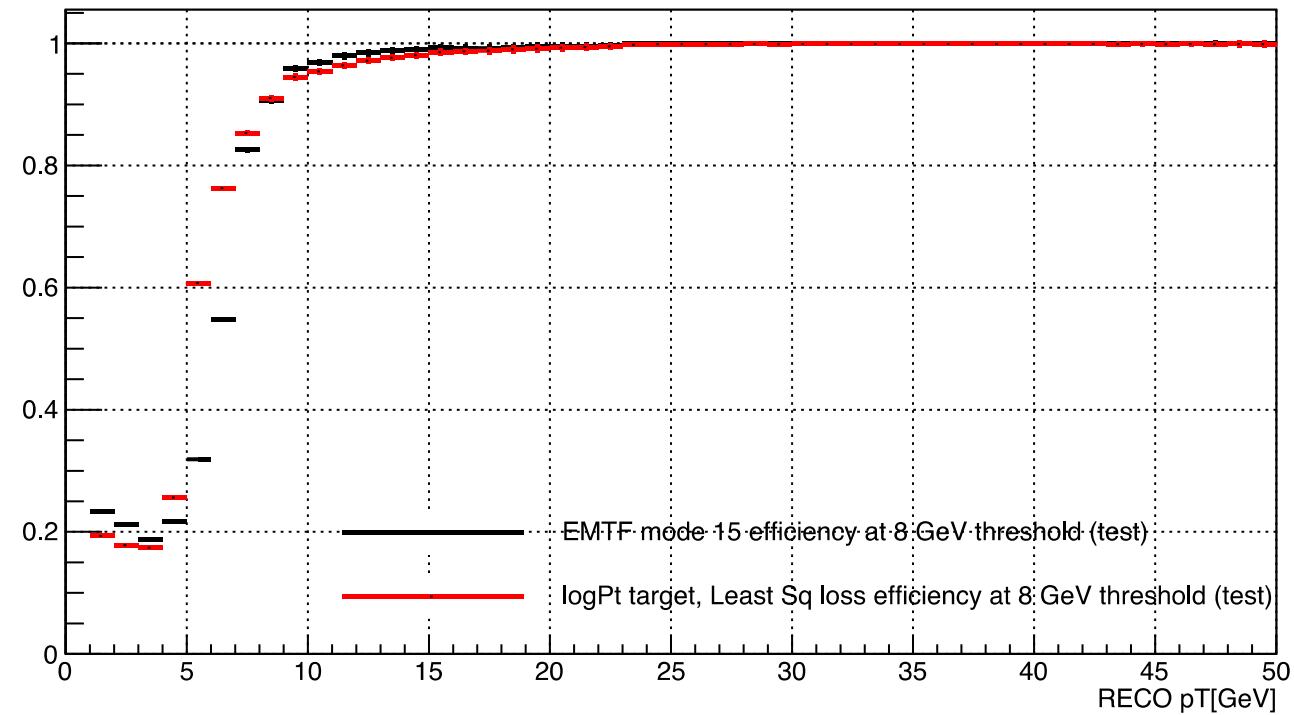
Basics

- 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
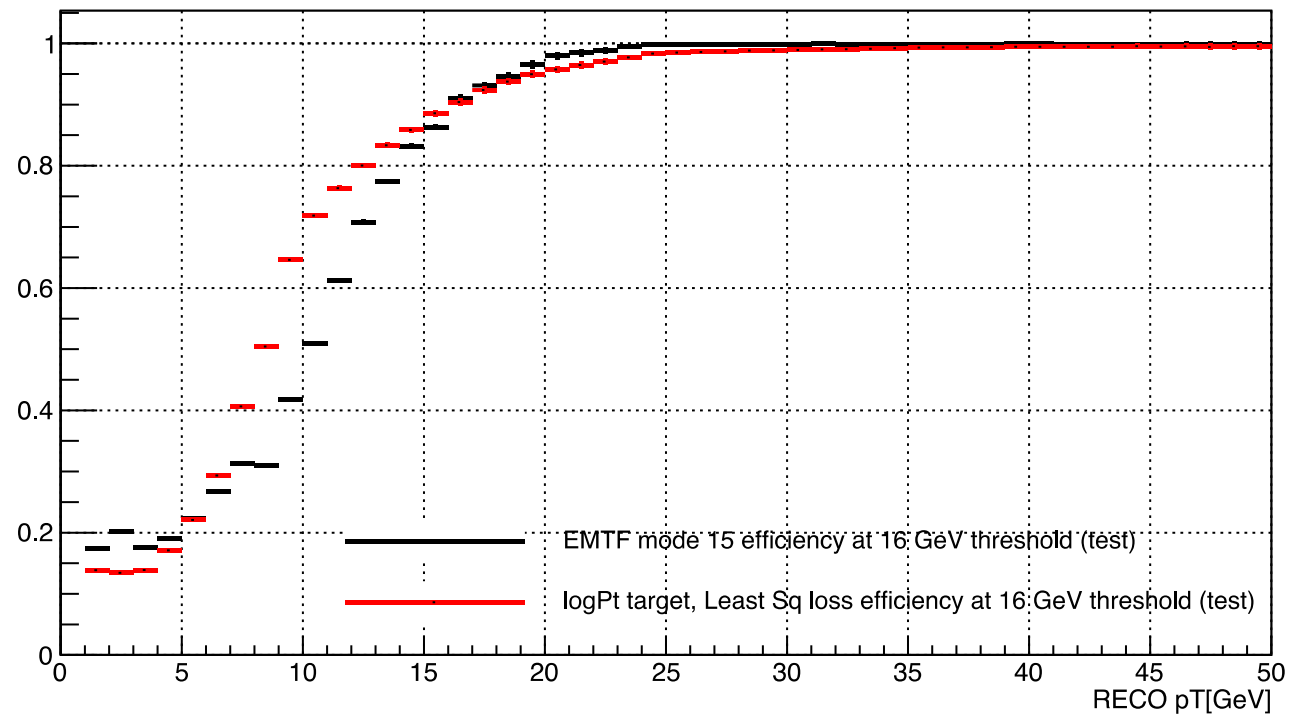 - Other BDT parameters same to 2017 BDT setting

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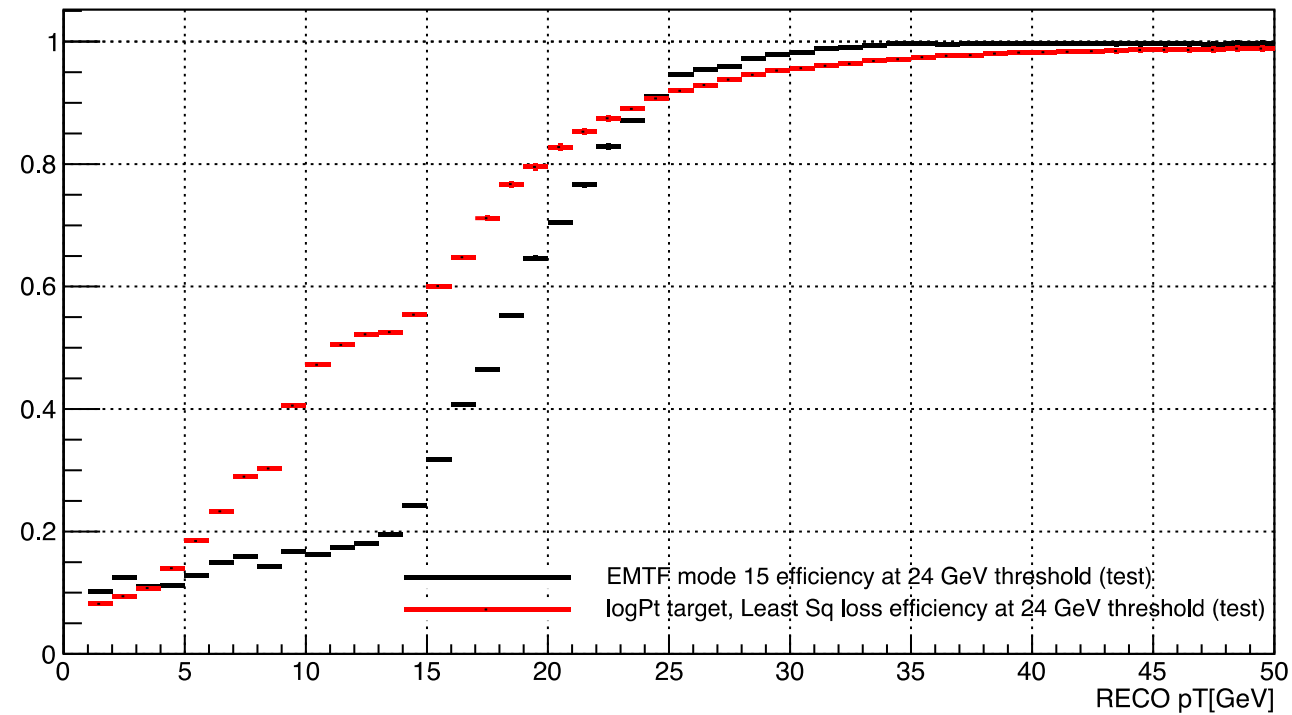[2] https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C#L412-L432

Efficiency @ 8GeV

Efficiency @ 16GeV

Efficiency @ 24GeV

weishi@rice.edu

Rate

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
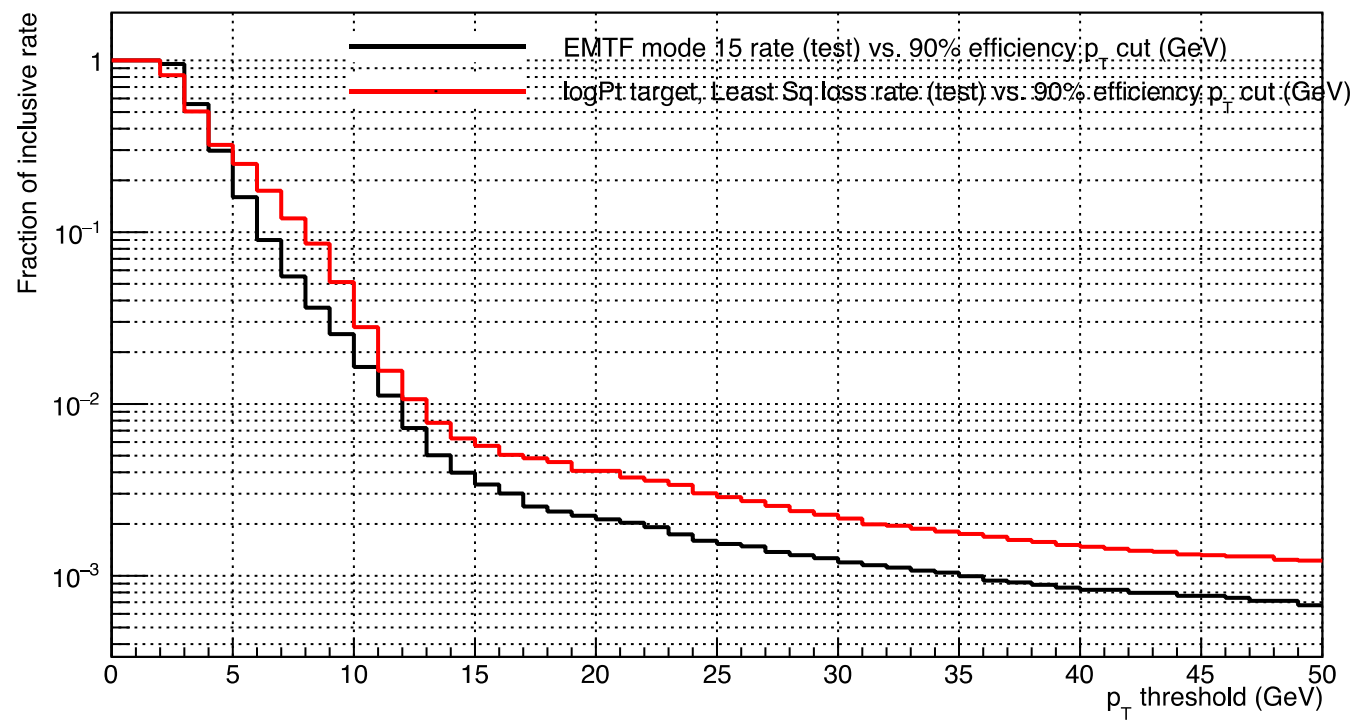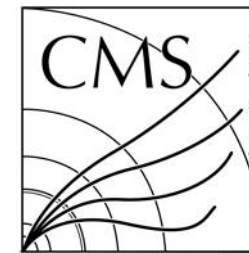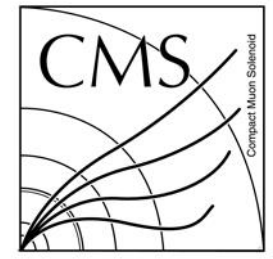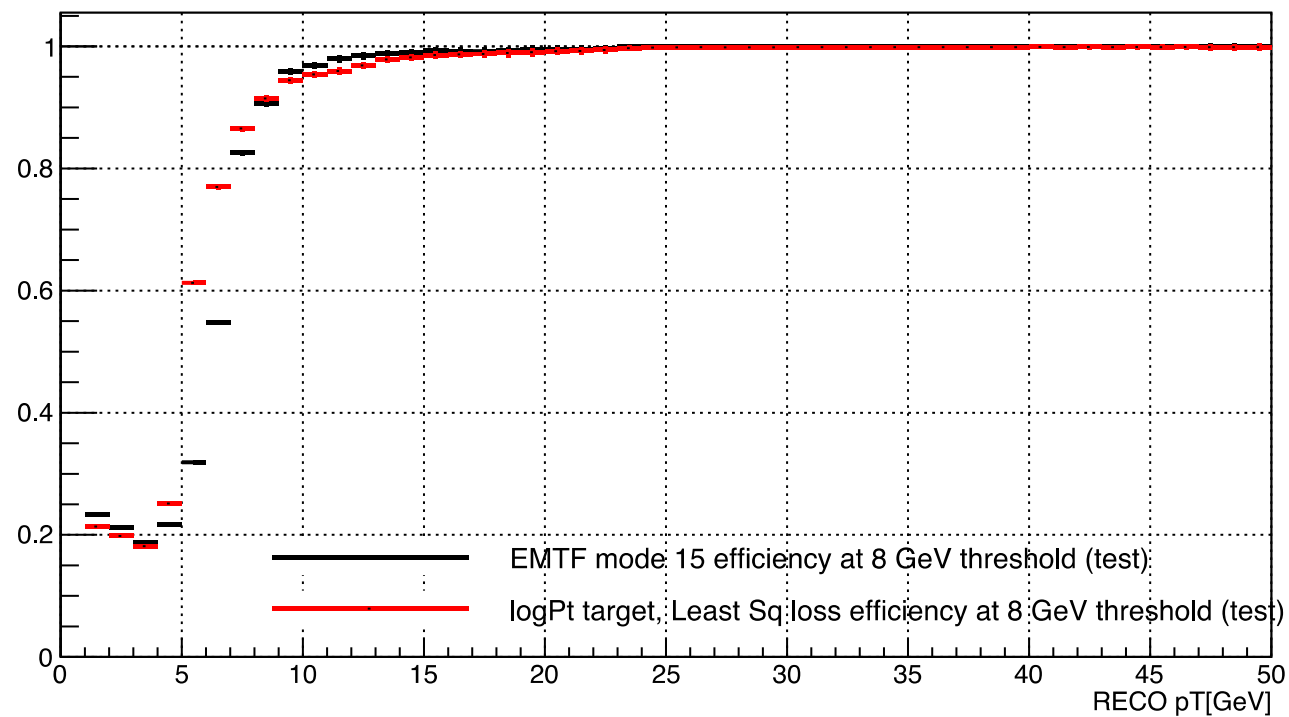
Efficiency @ 8GeV

EMTF mode 15 efficiency at 8 GeV threshold (test)

Efficiency @ 16GeV

EMTF mode 15 efficiency at 16 GeV threshold (test)

weishi@rice.edu
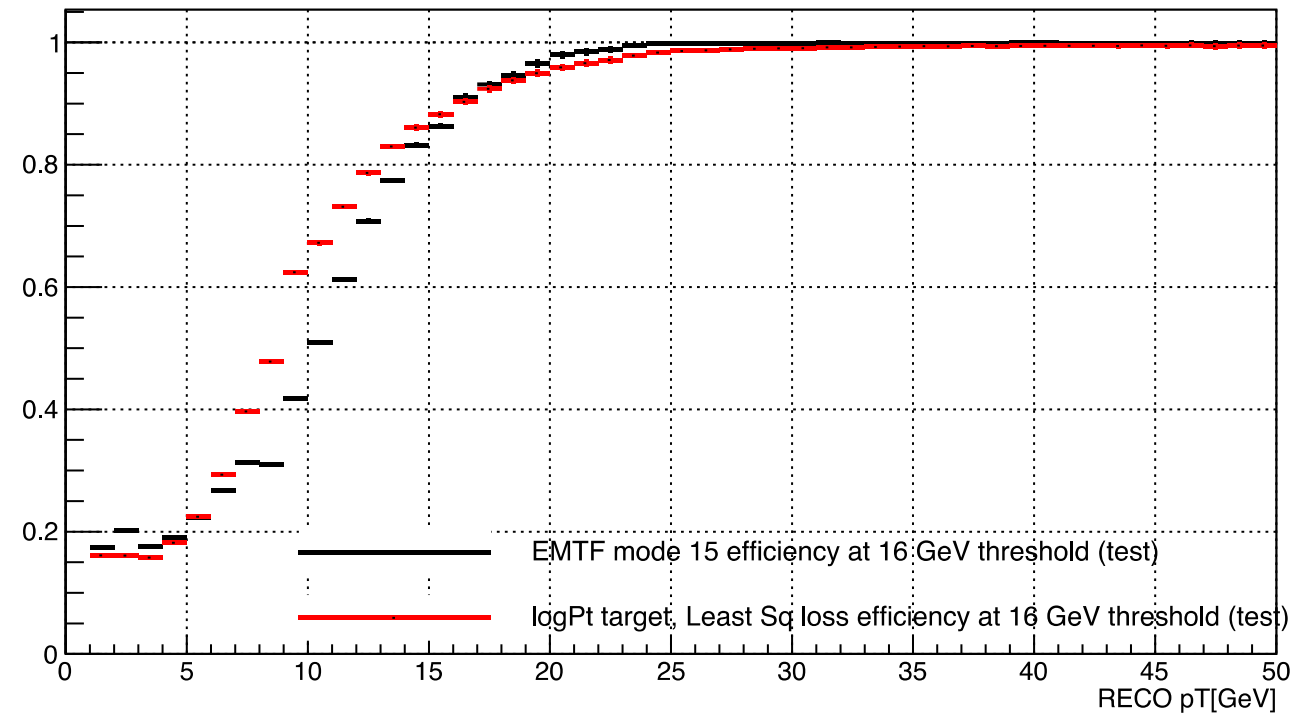
Efficiency @ 24GeV

EMTF mode 15 efficiency at 24 GeV threshold (test)
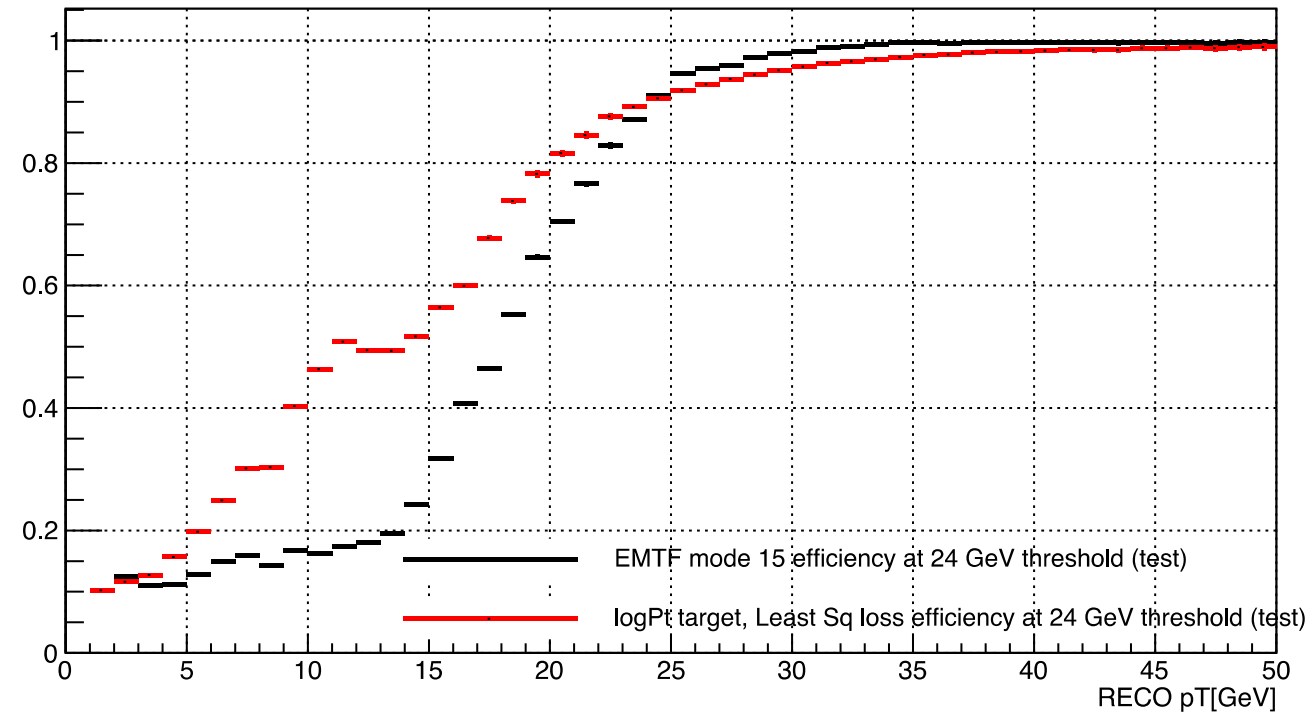
Rate
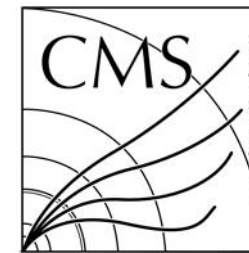
EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
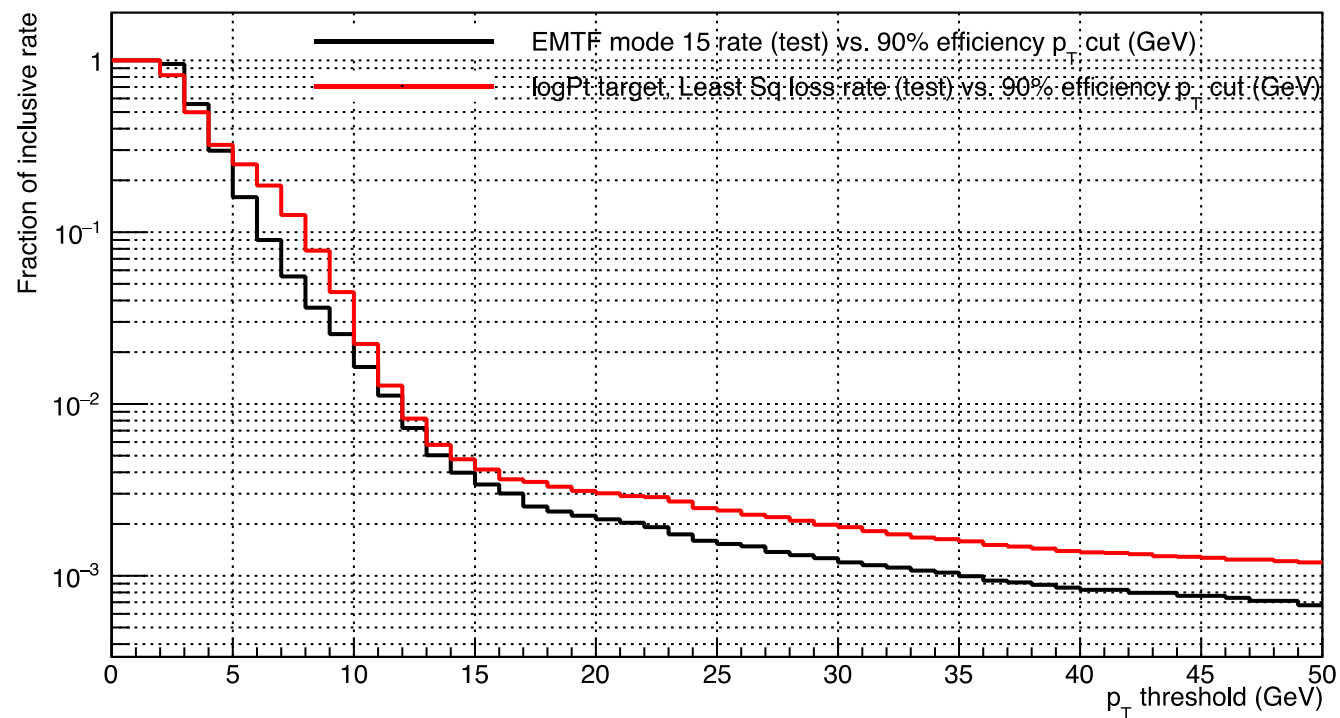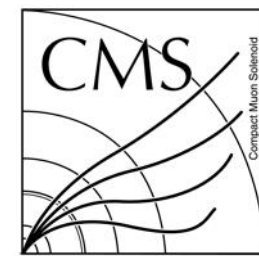
Basics

- 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
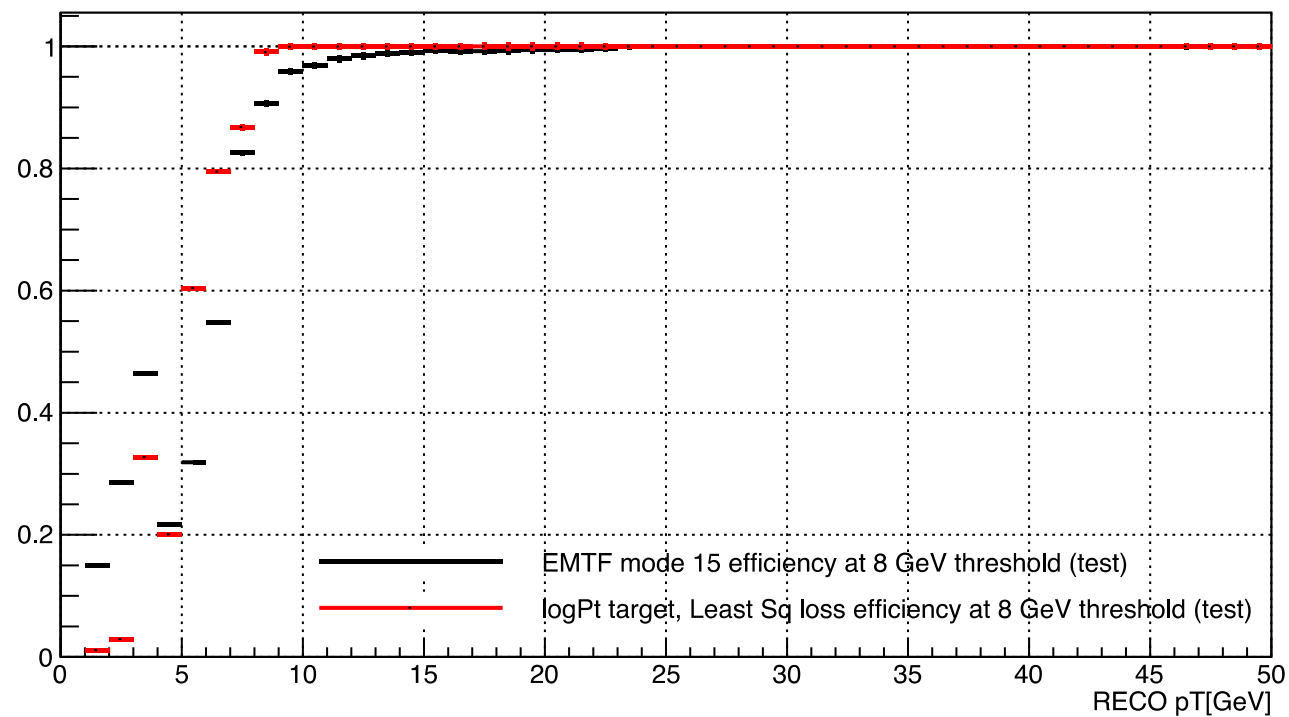
Efficiency @ 8GeV

Efficiency @ 16GeV
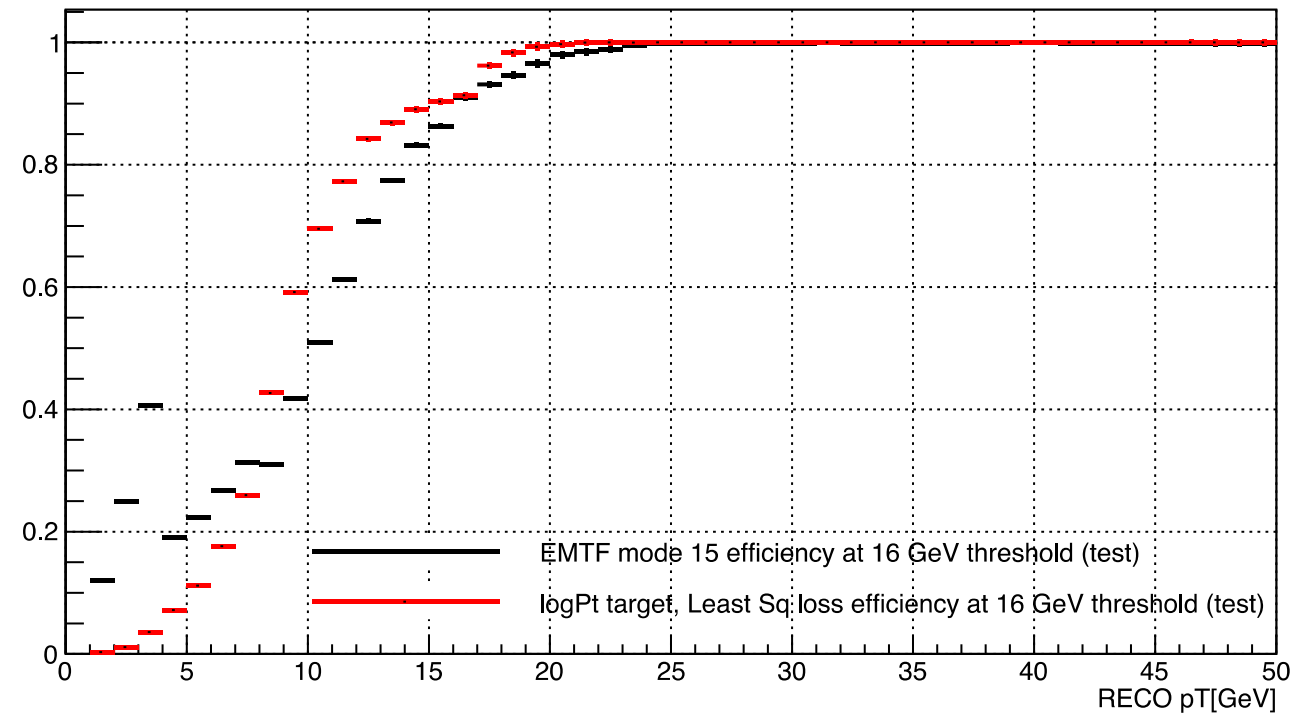
Efficiency @ 24GeV
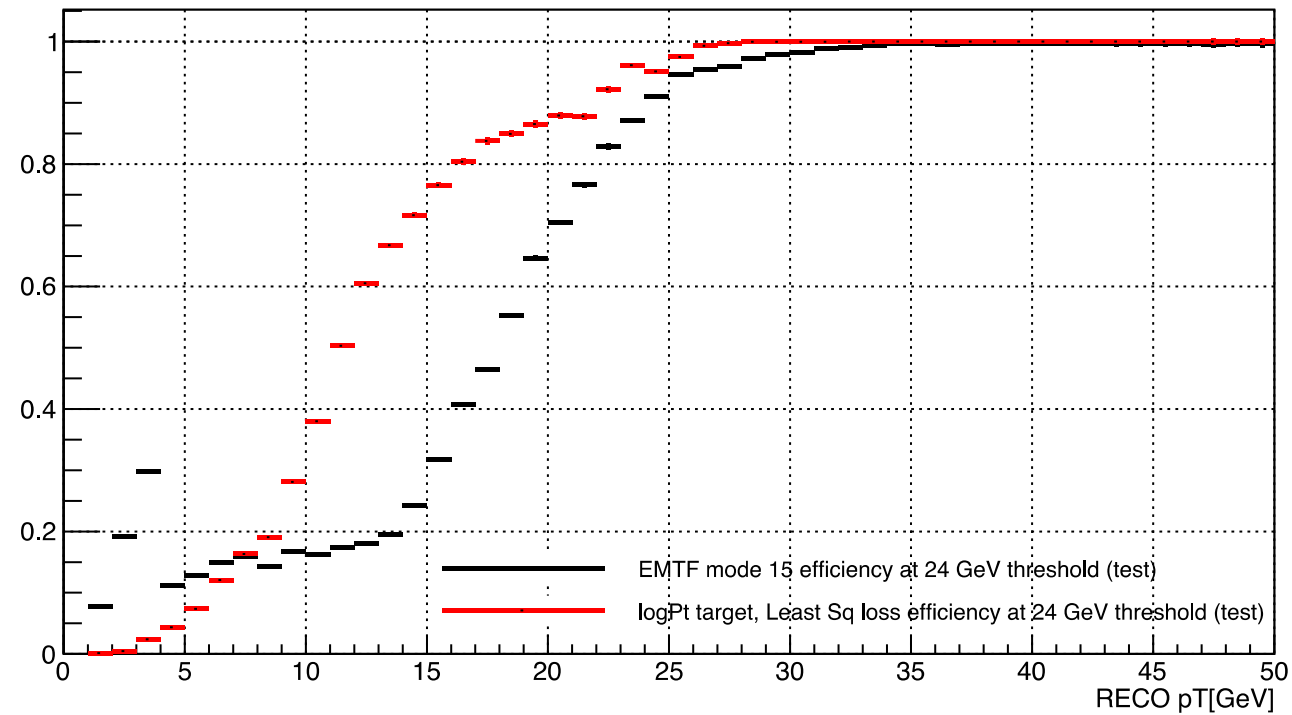
Rate
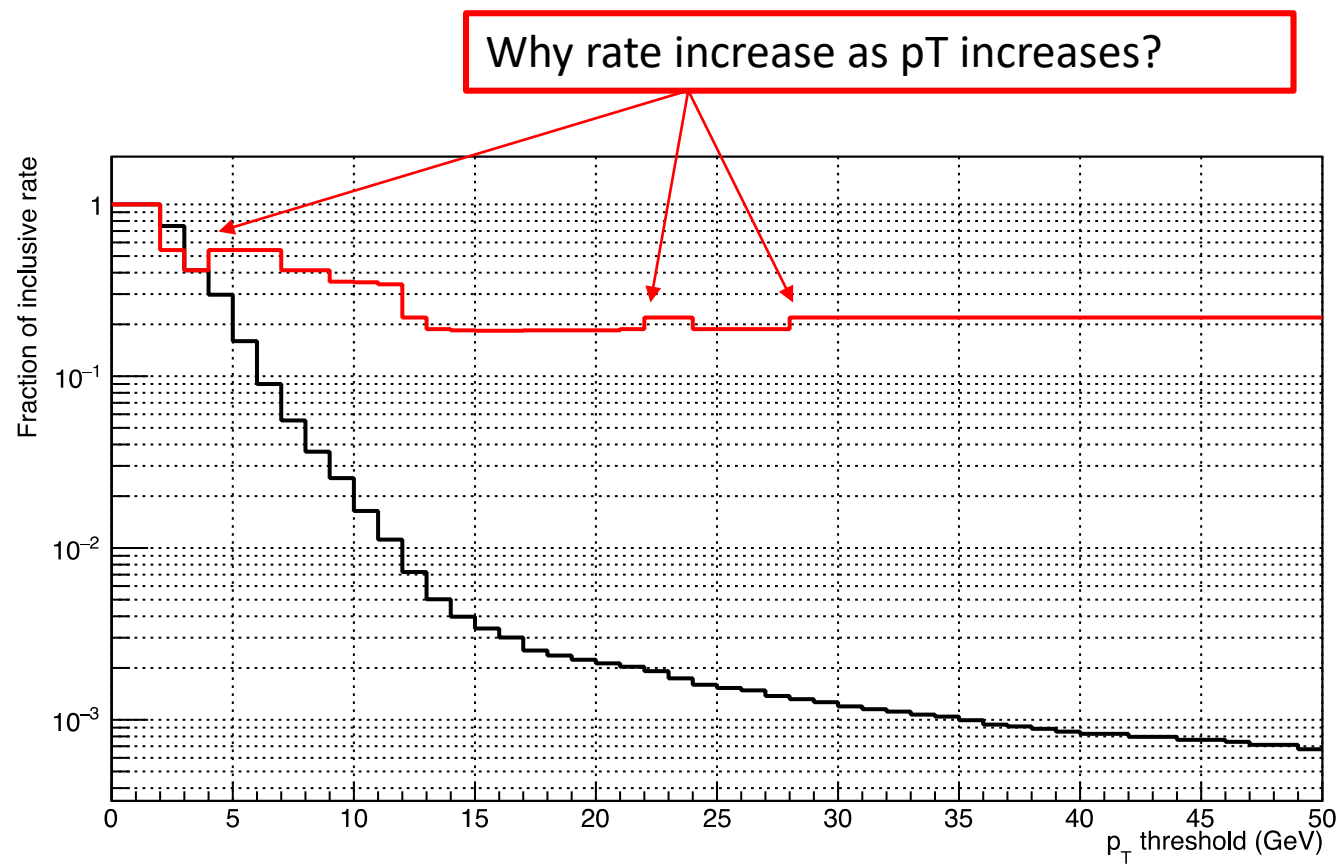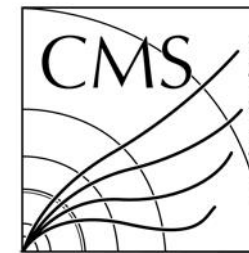
Compare Target

- 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

log2_GEN_pt_trg

[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
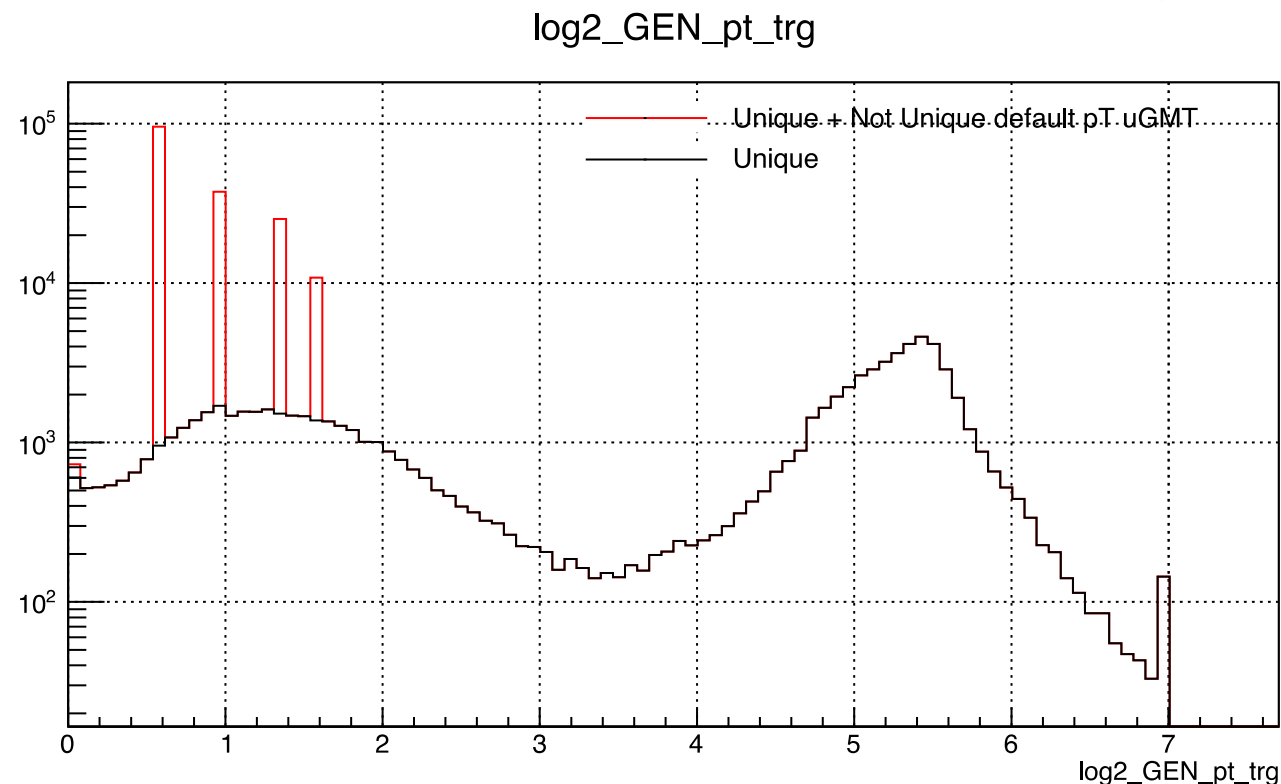
Compare pT Scale

logPt target, Least Sq loss (test) 90% efficiency scaling vs. p_T (GeV)

Entries	100
Mean	27.48
Std Dev	14.32

logPt target, Least Sq loss (test) 90% efficiency scaling vs. p_T (GeV)

Entries	100
Mean	33.34
Std Dev	11.97
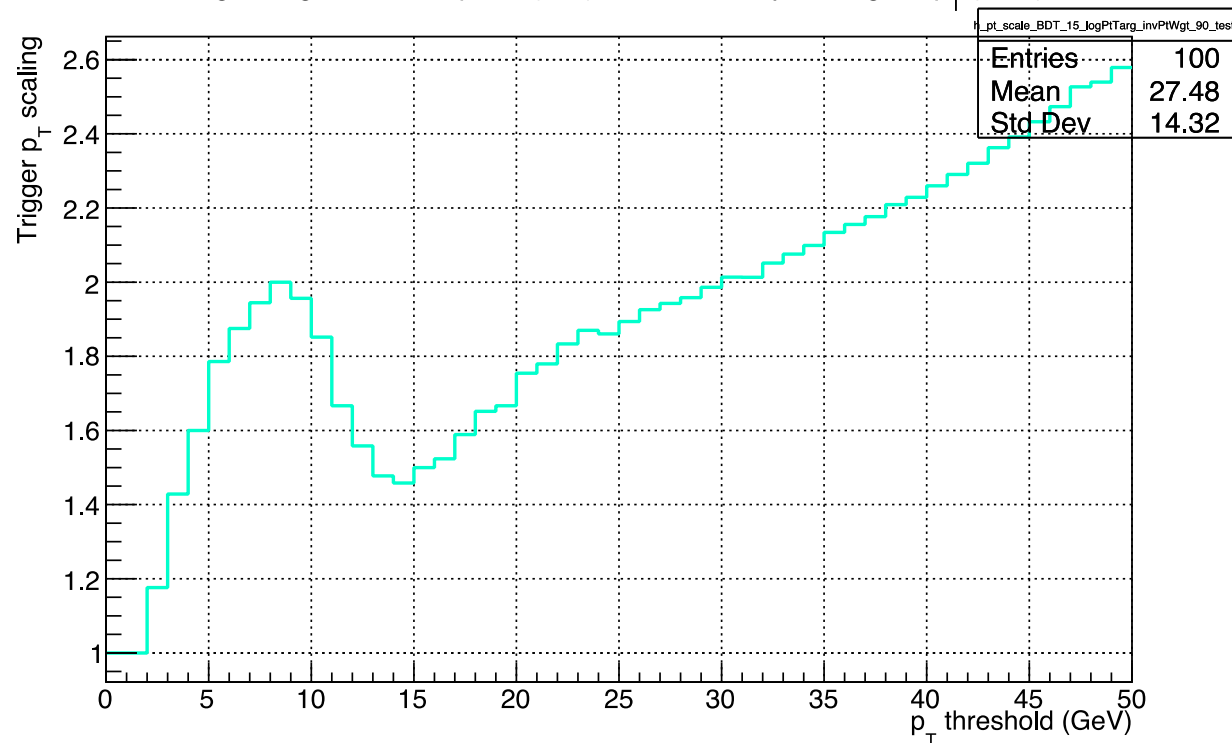
Uniquely matched Only
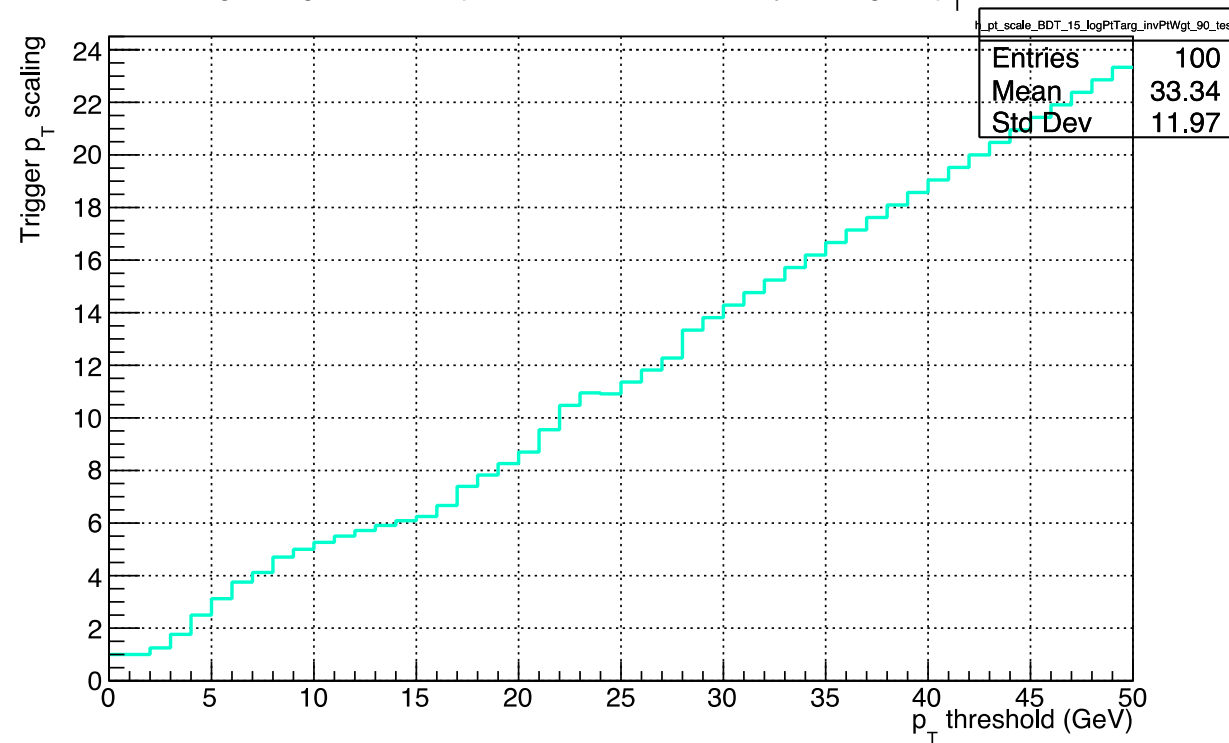
Include not uniquely matched
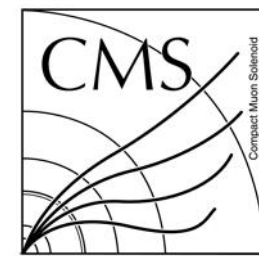
pT Scale @1% efficiency

EMTF mode 15 (test) 1% efficiency scaling vs. p_T (GeV)

h_pt_scale_EMTF15_1_test	
Entries	100
Mean	25
Std Dev	14.43
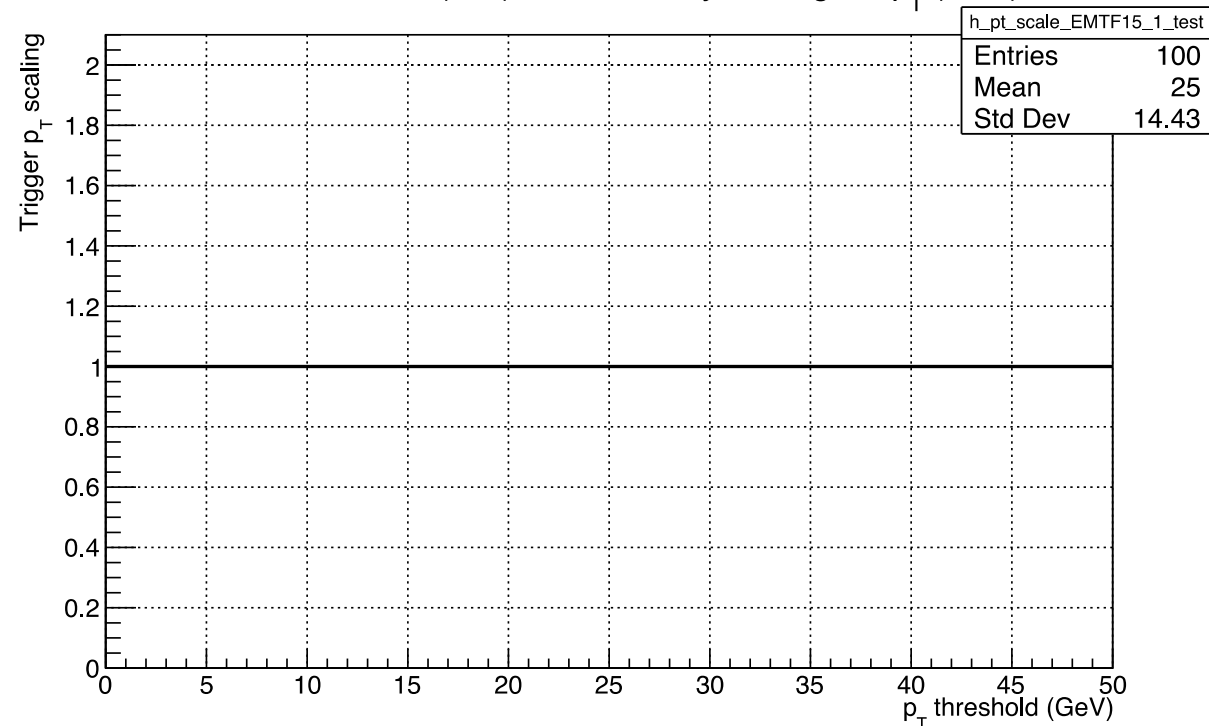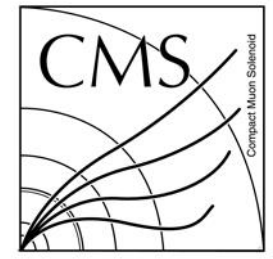
logPt target, Least Sq loss (test) 1% efficiency scaling vs. p_T (GeV)

h_pt_scale_BDT_15_logPtTarg_invPtWgt_1_test	
Entries	100
Mean	26.32
Std Dev	14.71
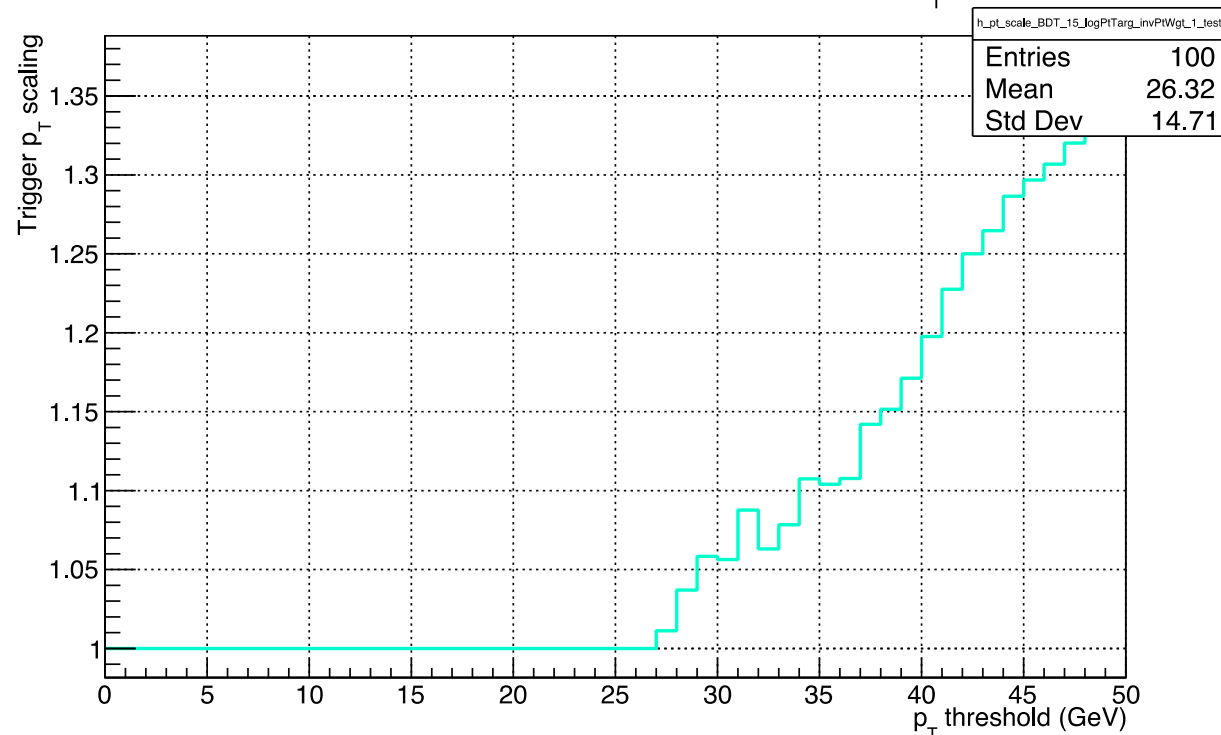
EMTF

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

EMTF mode 15 efficiency at 8 GeV threshold (test)

Efficiency @ 16GeV

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Efficiency @ 24GeV

weishi@rice.edu
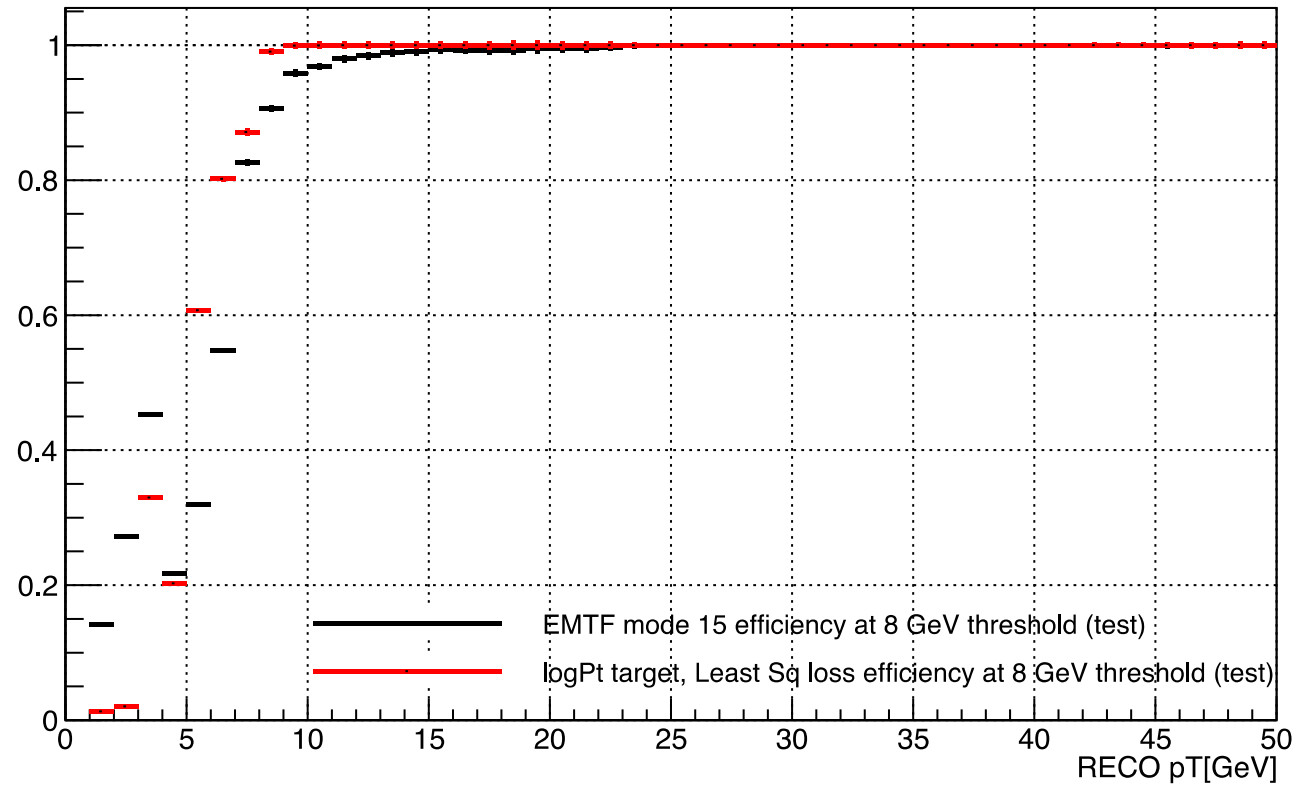
Rate

EMTF mode 15 rate (test) vs. 90% efficiency p_T cut (GeV)
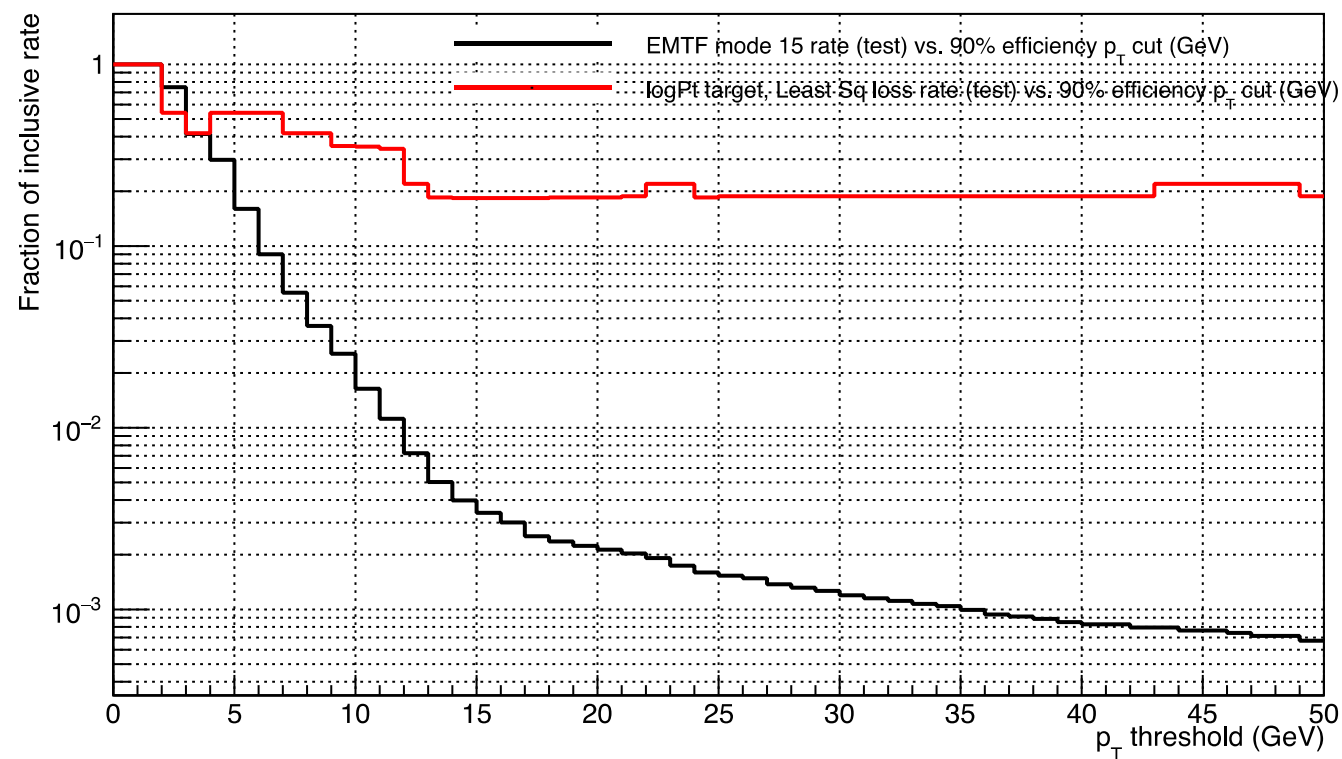
Trk_pT from one SingleMu file

trk_pt

Legend:
- trk_pt
- trk_pt {trk_dR_match_unique==1}
- trk_pt {trk_dR_match_unique!=1}
- trk_pt {trk_dR_match_nReco+trk_dR_match_nRecoSoft==0}
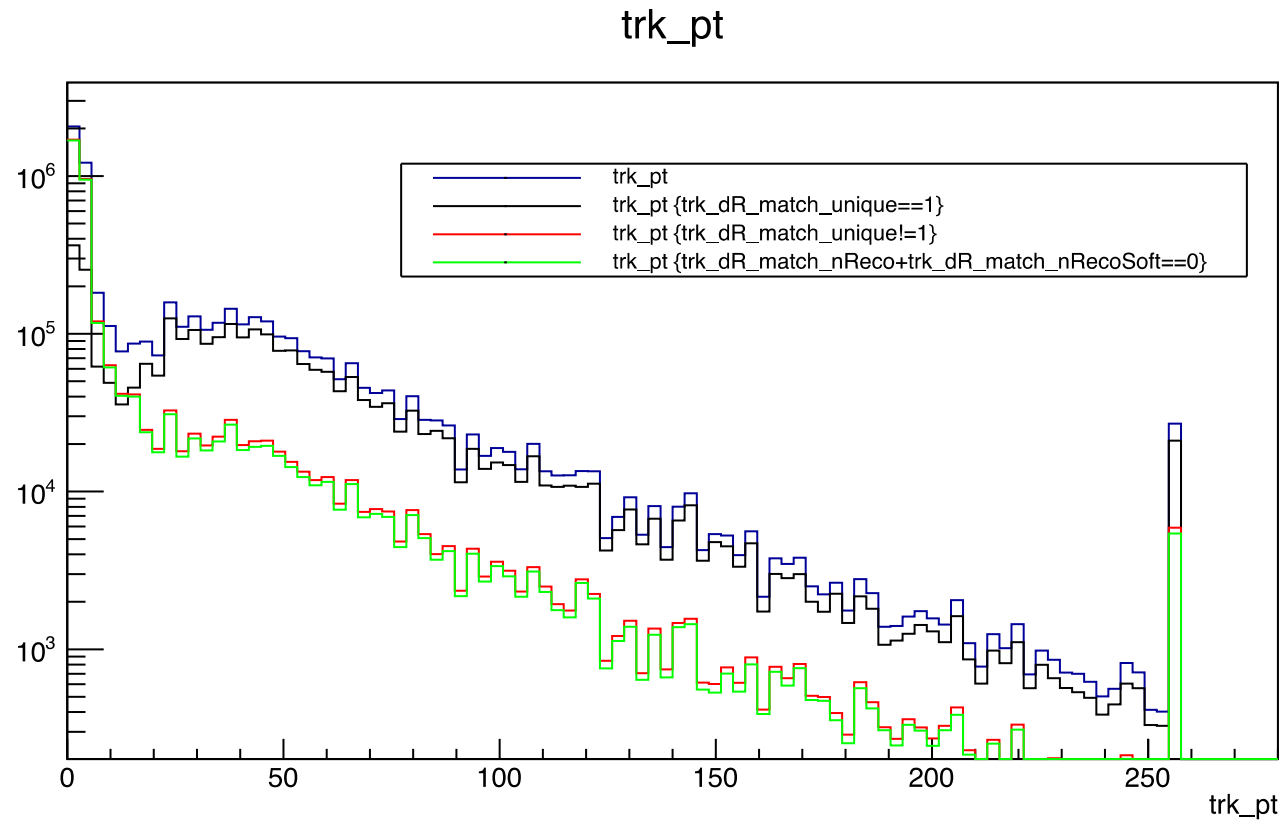
Back Up
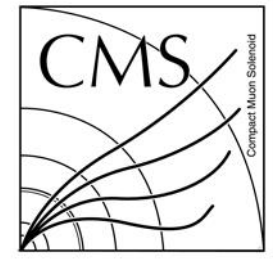
Additional Info

- 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
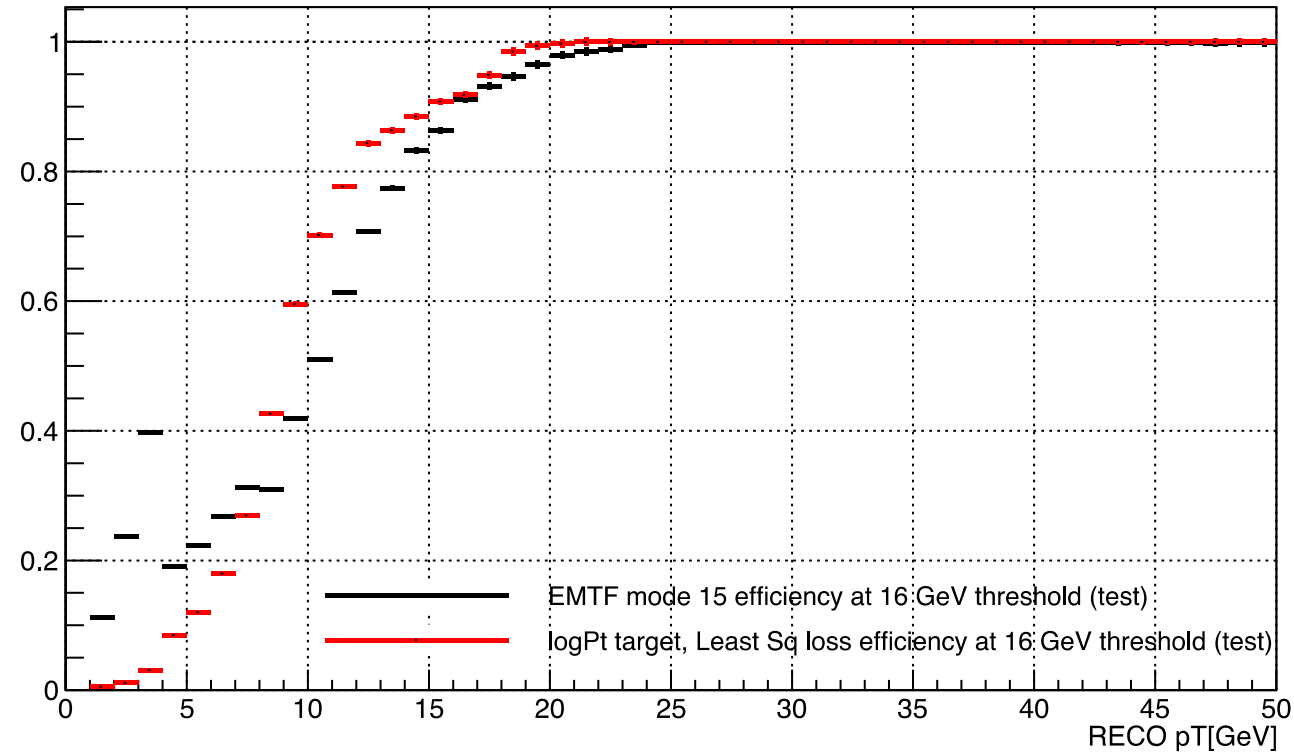[2] https://github.com/weishi10141993/EMTFPtAssign2017/blob/test/PtRegression2018.C#L412-L432
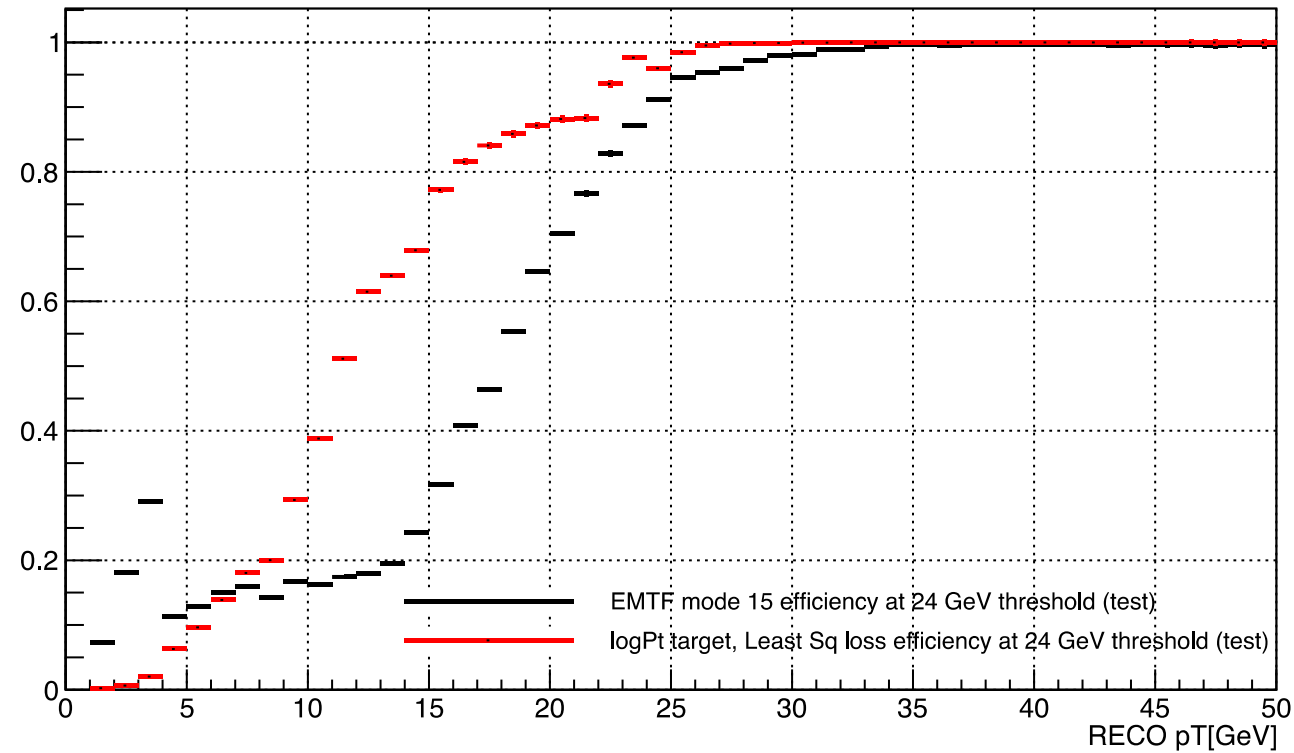
Efficiency @ 8GeV

Efficiency @ 16GeV

Efficiency @ 24GeV

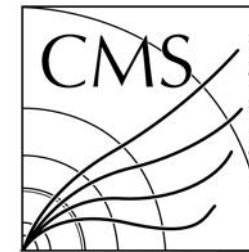weishi@rice.edu

Rate

weishi@rice.edu

Back Up

weishi@rice.edu
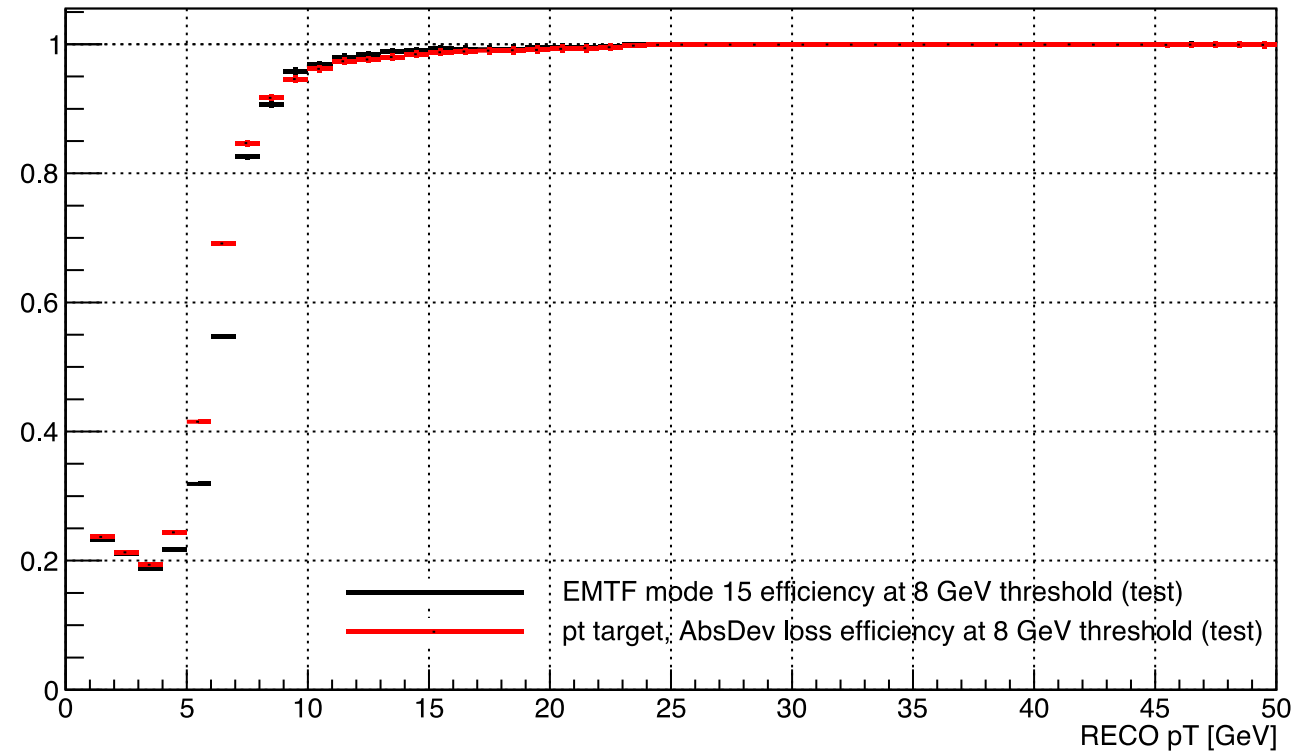
Some Useful info from TMVA

```
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
----------------------------------------------------------------------------------------------------------------------------------
```
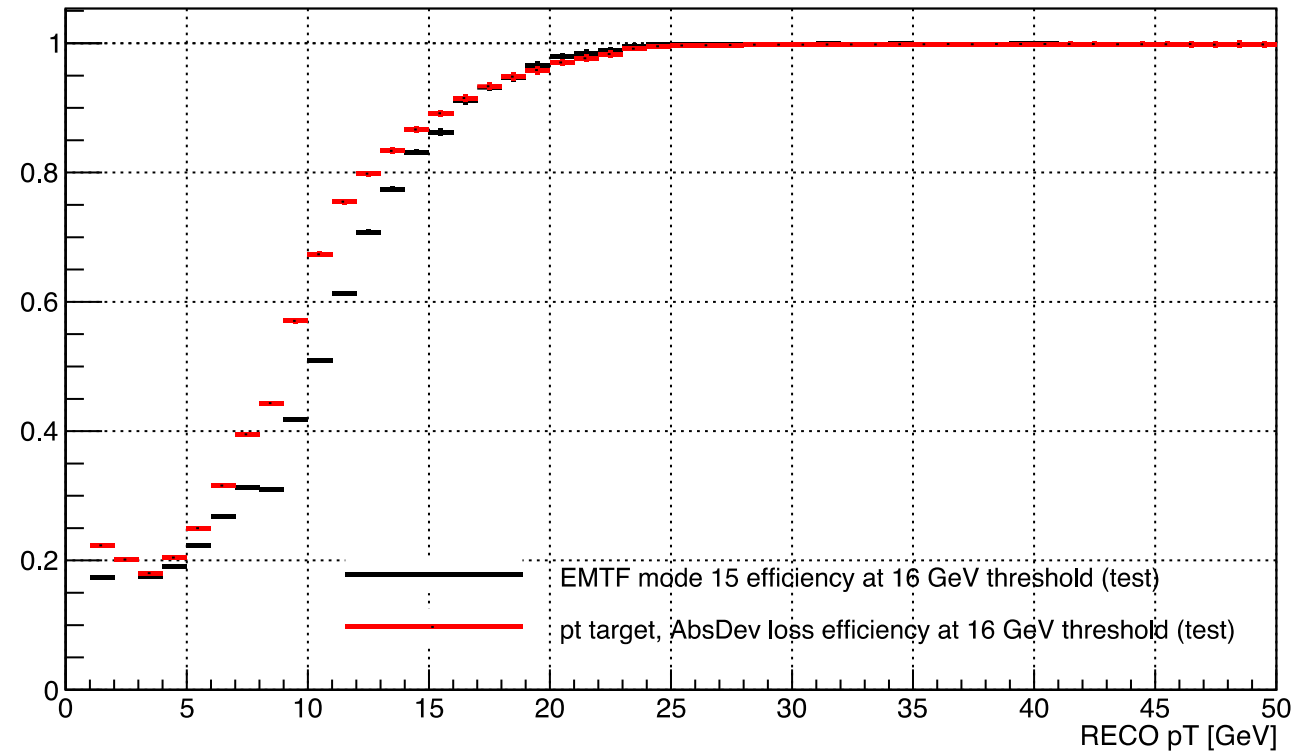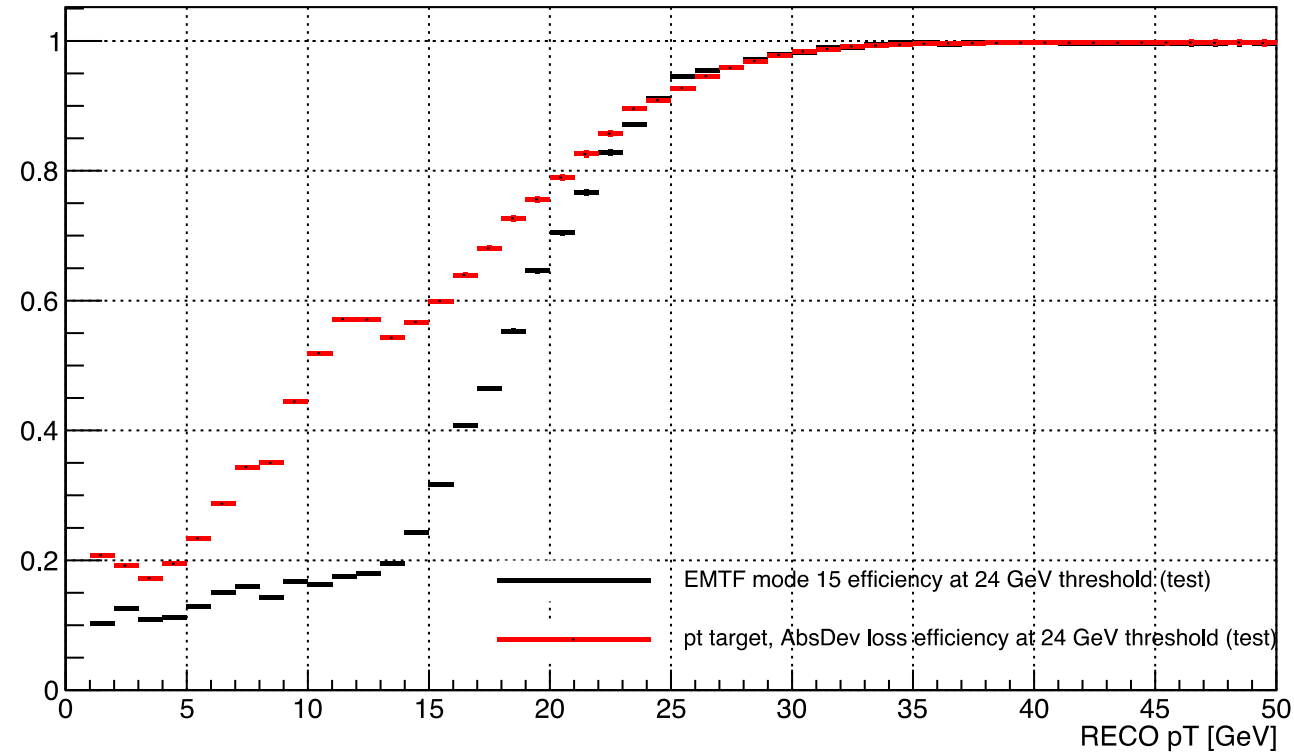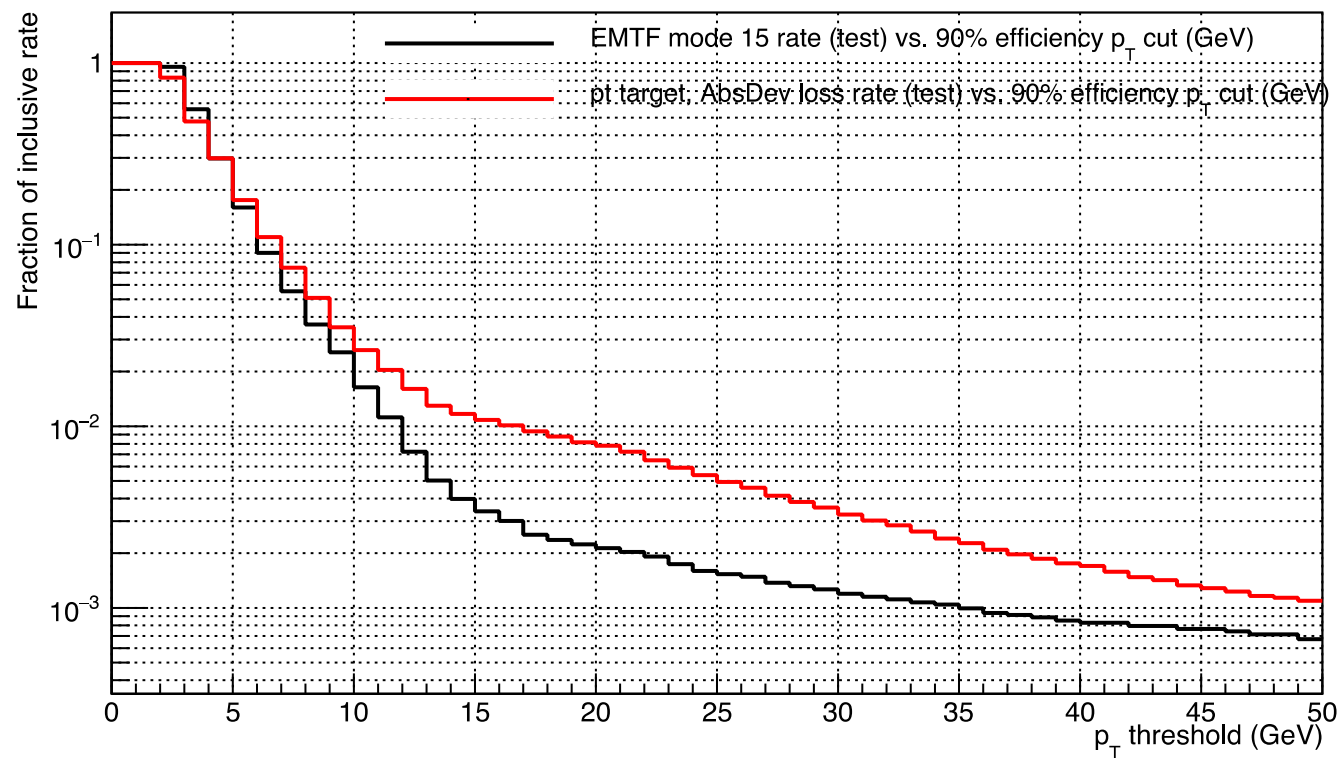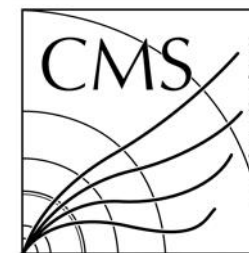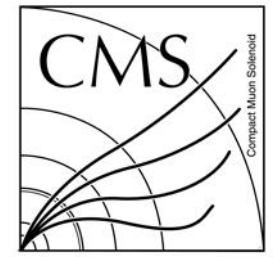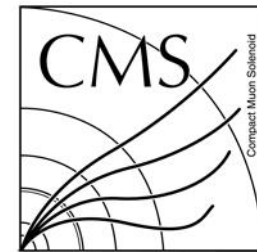
weishi@rice.edu
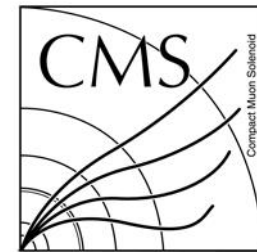
Some Useful info from TMVA

```
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

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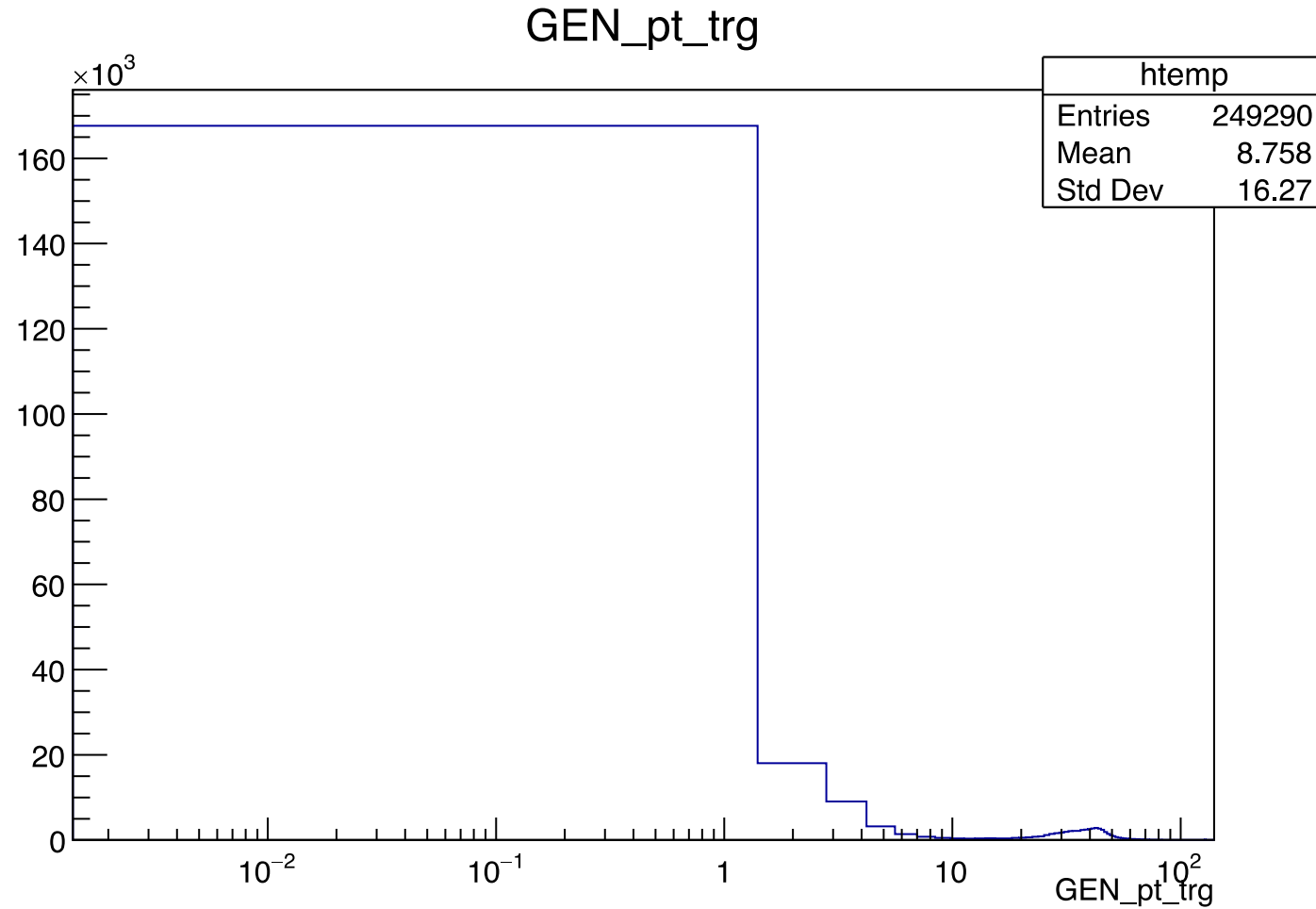
- Set RECO pT=1GeV, eta, phi, charge same as EMTF track

Include tracks not uniquely matched

BDTG_AWB

htemp	
Entries	249290
Mean	1
Std Dev	0
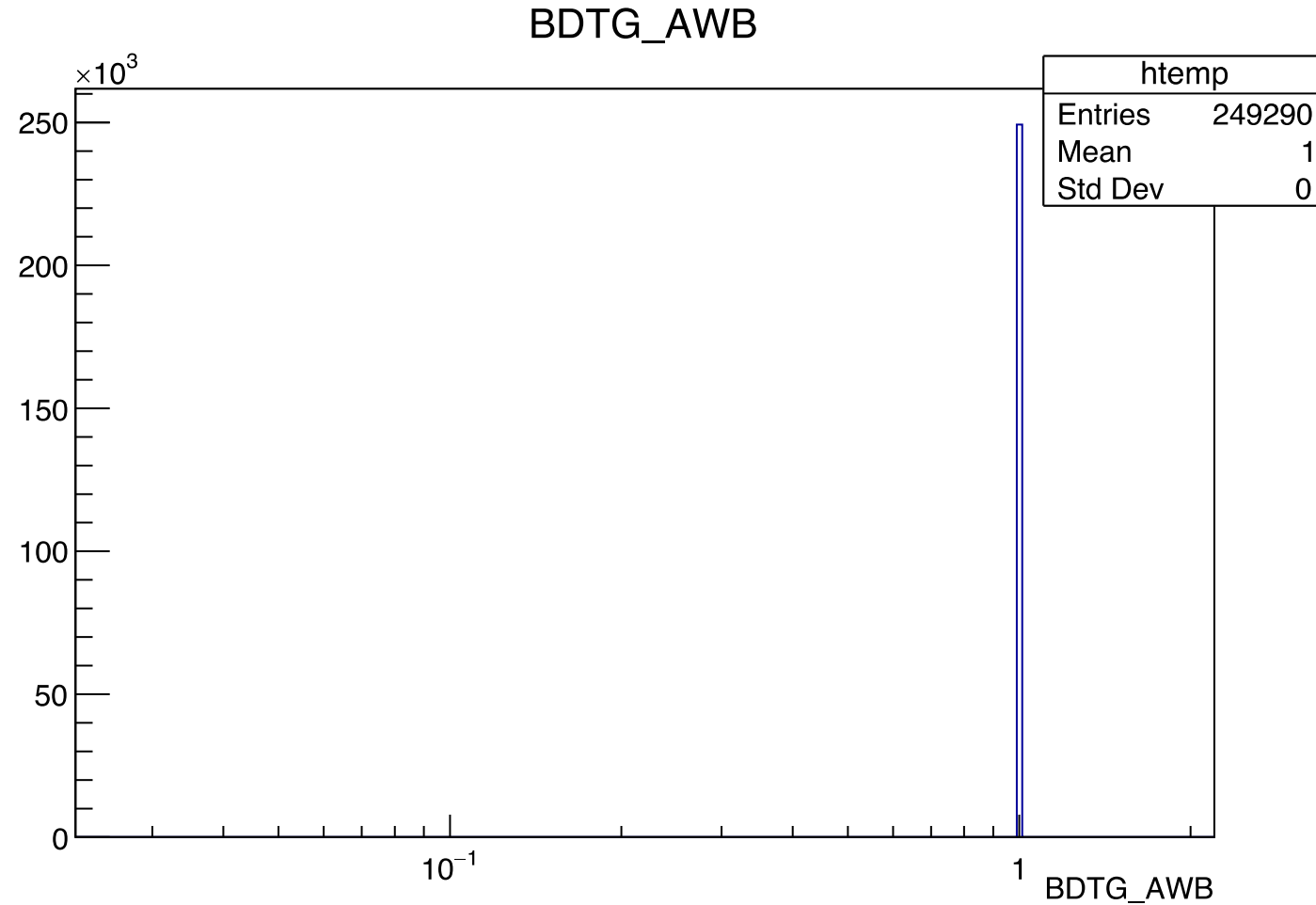
- /eos/user/w/wshi/2018PtTraining/Mode15PtTargNoWgtAbsDevUniquelyMatched_plus_NotUniquelyMatch edRECO1GeV