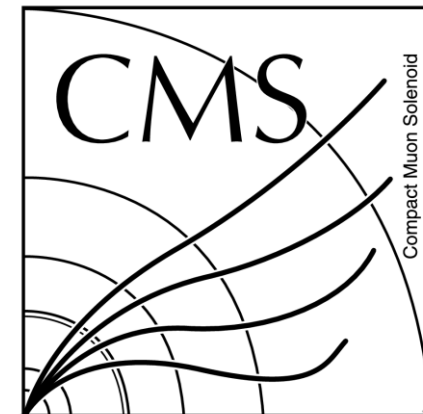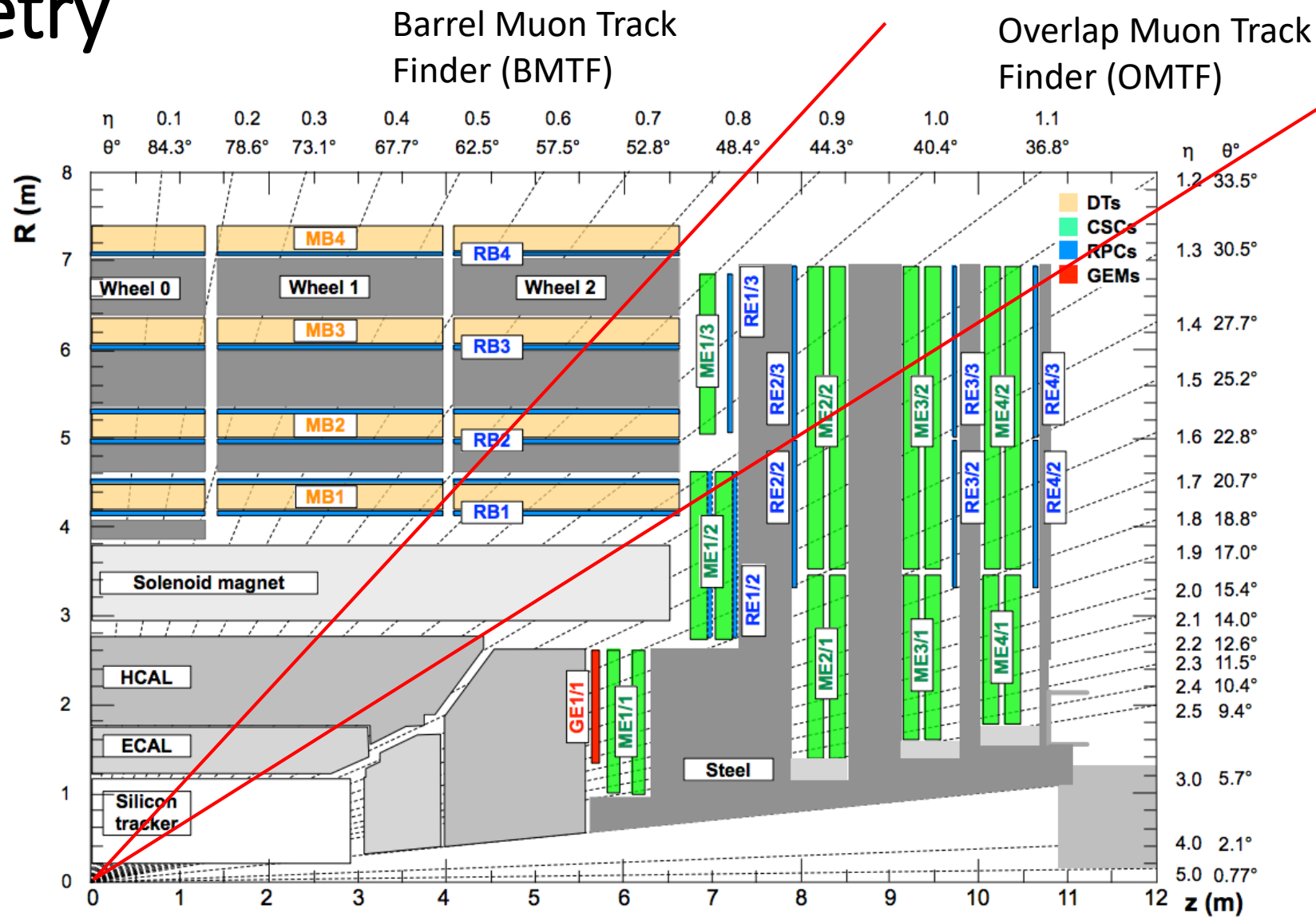# 2018 EMTF Algorithm Changes Proposal

L1 DPG Meeting
May 14, 2018

Wei Shi on behalf of the

EMTF working group

Geometry

Overview

- Proposed algorithm changes in 2018
  - ➢Reduce track building BX window: 3→2
  - ➢Remove 2-station tracks with different hit BX [1]
  - ➢Reduce maximum $\Delta\theta$ for "Zone 0" (ring 1): 8 → 4
  - ➢Resolve $\Delta\theta$ ambiguity when multiple LCTs are in the same chamber
  - ➢Revise map between track mode and quality [1]

[1] https://indico.cern.ch/event/719916/contributions/2959195/attachments/1629473/2596583/EMTF_Studies_on_Reco_Muons.pdf

Motivations (I)

➢Track building BX window: 3→2
- Track building: CSC LCTs or RPC hits correlated in theta (±2°) and phi (±8° in station 1, ±4° in stations 2 - 4)
- LCT mistiming rate: <1% (conservative)
- Tracks in BX = 0 can now include LCTs from BX = -1 and 0, or BX = 0 and +1, but not from BX = -2 or +2, and not both -1 and +1

➢2-station tracks with different hit BX removed [1]
- Track BX: 2nd-earliest LCT or RPC hit in the track
- 2-station track affected most by mistimed LCT

[1] https://indico.cern.ch/event/719916/contributions/2959195/attachments/1629473/2596583/EMTF_Studies_on_Reco_Muons.pdf

Motivations (II)

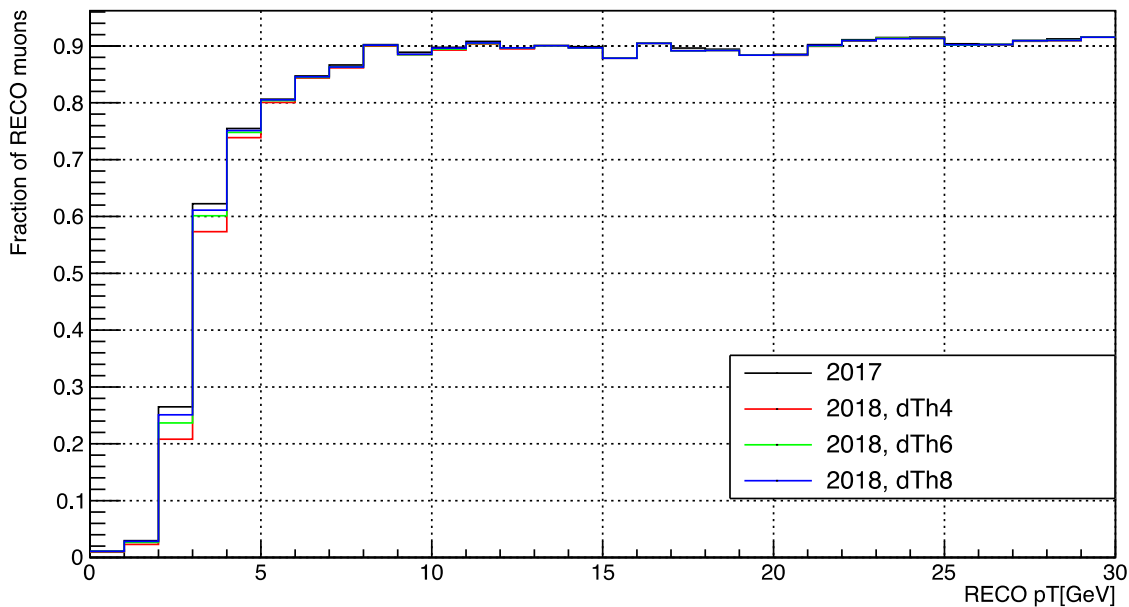➢ Reduce max Δθ for "Zone 0" from 8 to 4

- Each LCT is assigned to zones based on θ
- Zone 0 roughly covers CSC ring 1 ($|\eta| > 1.7$), does not include RPC hits
- Wide $\Delta\theta$ windows (8 units, ~2°) not necessary, and add rate from PU

➢ Resolve $\Delta\theta$ ambiguity when multiple LCTs are in the same chamber
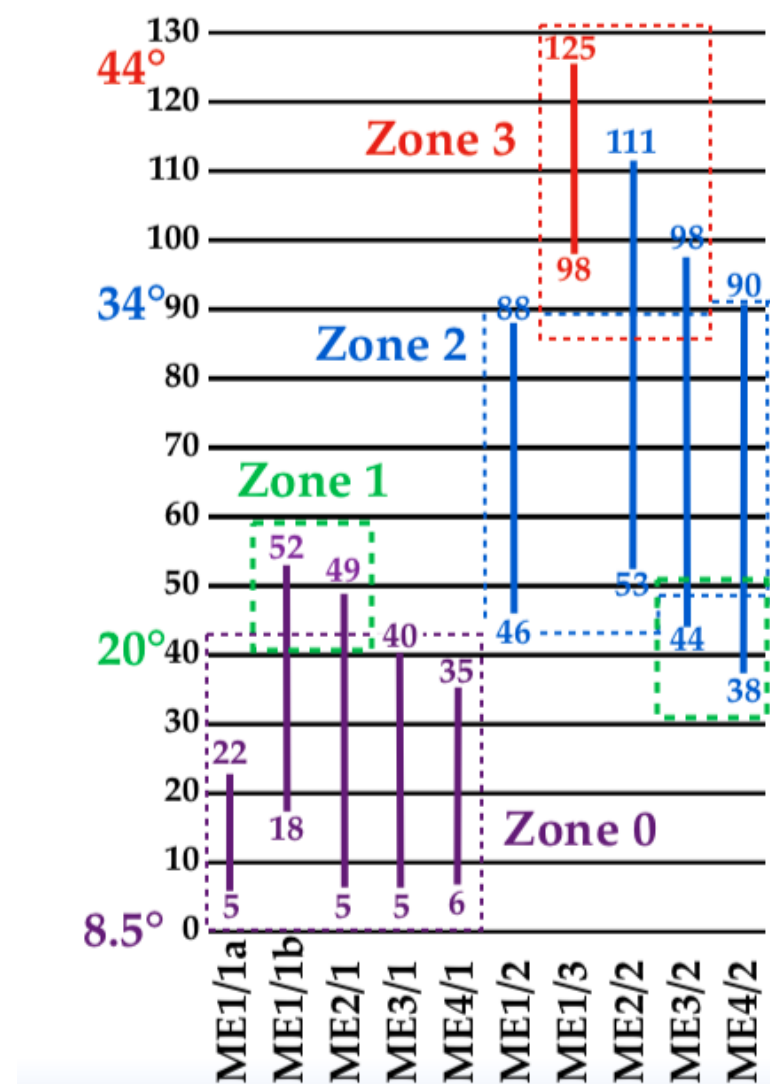
A. Brinkerhoff

Motivations (III)

➢Revised map b/t track mode and quality
- Earlier study [1] showed dominant contribution to DoubleMu quality rate from mode 12 with small efficiency
- Demote mode 12 to MuOpen
- Promote mode 9 to DoubleMu
  - Compensate efficiency loss due to demoting mode 12

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

[1] https://indico.cern.ch/event/719916/contributions/2959195/attachments/1629473/2596583/EMTF_Studies_on_Reco_Muons.pdf

Selections

- Remove trigger bias
  - "HLT_IsoMu27" or "HLT_Mu50" in run 306154
  - Use RECO muons
    - Events with 2 or more fired the trigger
    - From the endcap when only 1 barrel muon fired trigger
- Selection on RECO muons
  - $|\eta|$@vertex and$|\eta|$@ME1 $\in$ (1.25, 2.4)
  - ID
    - pT < 8 GeV: loose && soft or medium
    - 8 < pT < 64 GeV: medium [2]
    - pT > 64 GeV: tight
- Rate
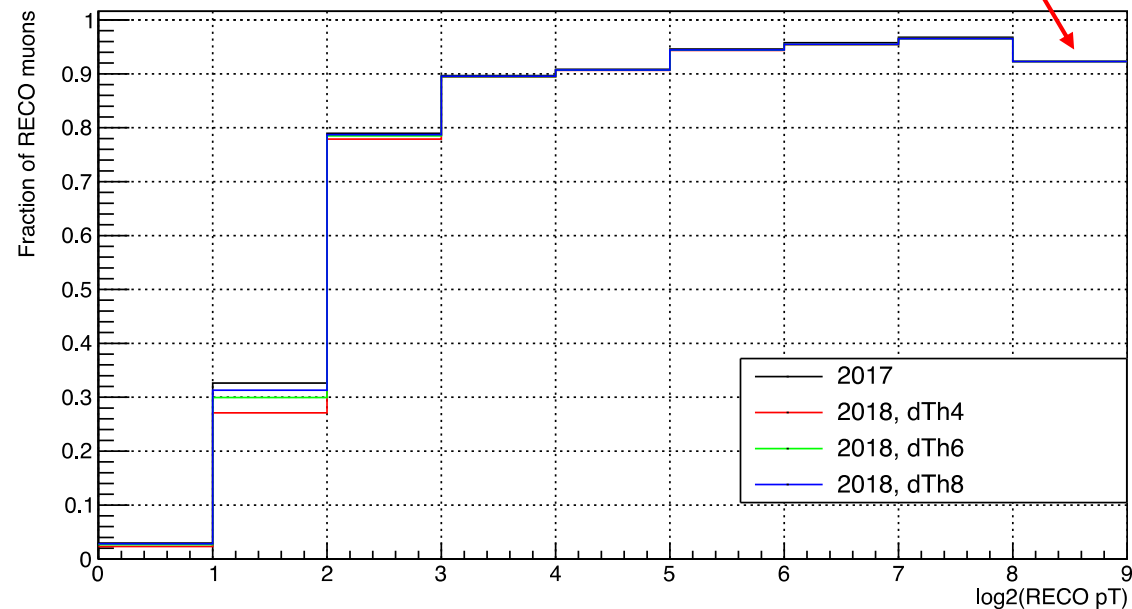 - Track BX=0, $|\eta|$>1.25
  - Use Zerobias data from run 306091 (PU 55 - 75)

[2] https://indico.cern.ch/event/357213/contributions/1769745/attachments/710701/975626/muonid-pog081214.pdf

SingleMu: Efficiency

Include pT > 256 GeV

- $\Delta\theta = 4$
  - No change in efficiency for pT > 4 GeV
  - Marginal affect on efficiency in 2-4 GeV range

SingleMu: Rate

SingleMu
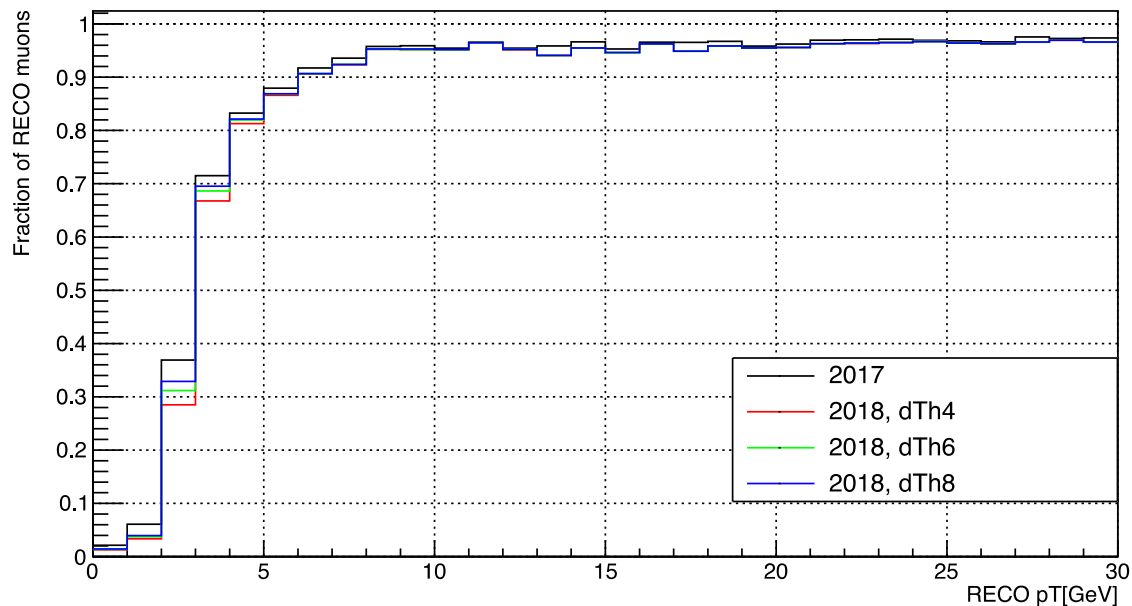
Legend (left plot):
- 2017
- 2018, dTh4
- 2018, dTh6
- 2018, dTh8

Δθ ambiguity

2BX window

SingleMu

Legend (right plot):
- 2018, dTh4
- 2018, dTh6
- 2018, dTh8
- 2017 + 2BX + 0 dBX

0 dBX only apply to 2-station tracks, no effect for SingleMu modes
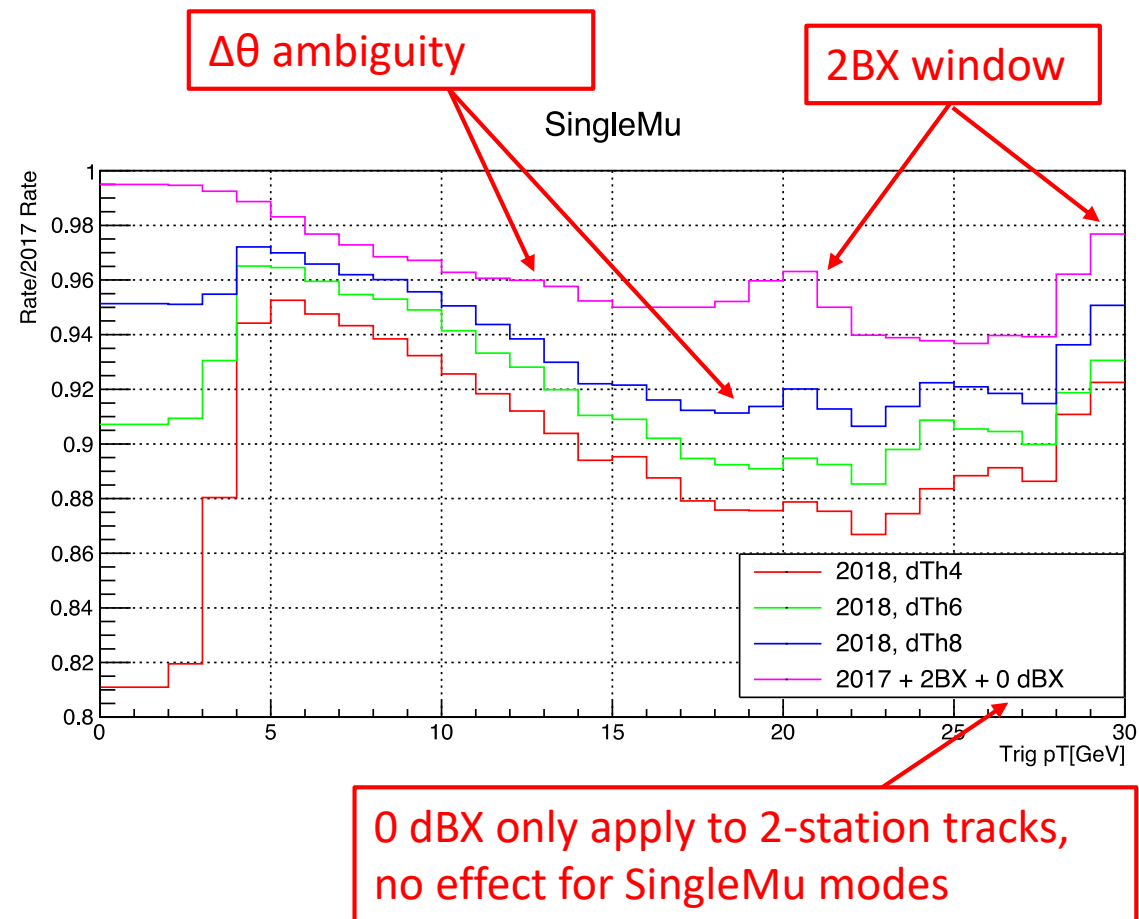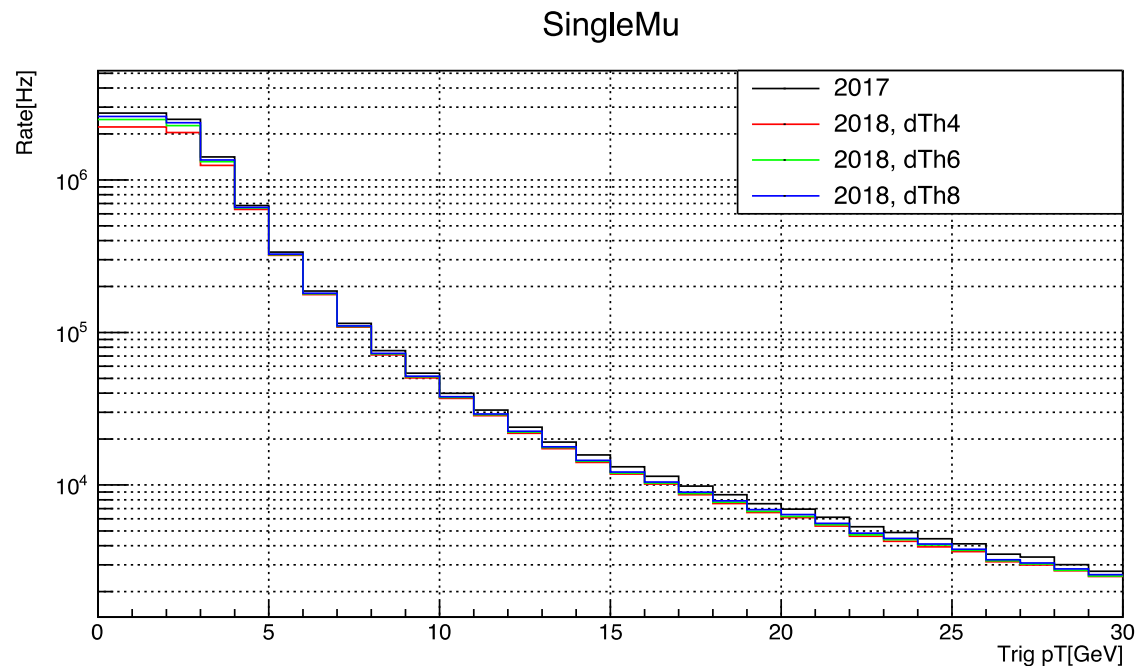
- $\Delta\theta$ = 4 reduces 13% rate for pT=22 GeV without efficiency loss in SingleMu quality

DoubleMu Inclusive: Efficiency

DoubleMu Inclusive: IsRecoMatch && BX0

DoubleMu Inclusive: IsRecoMatch && BX0
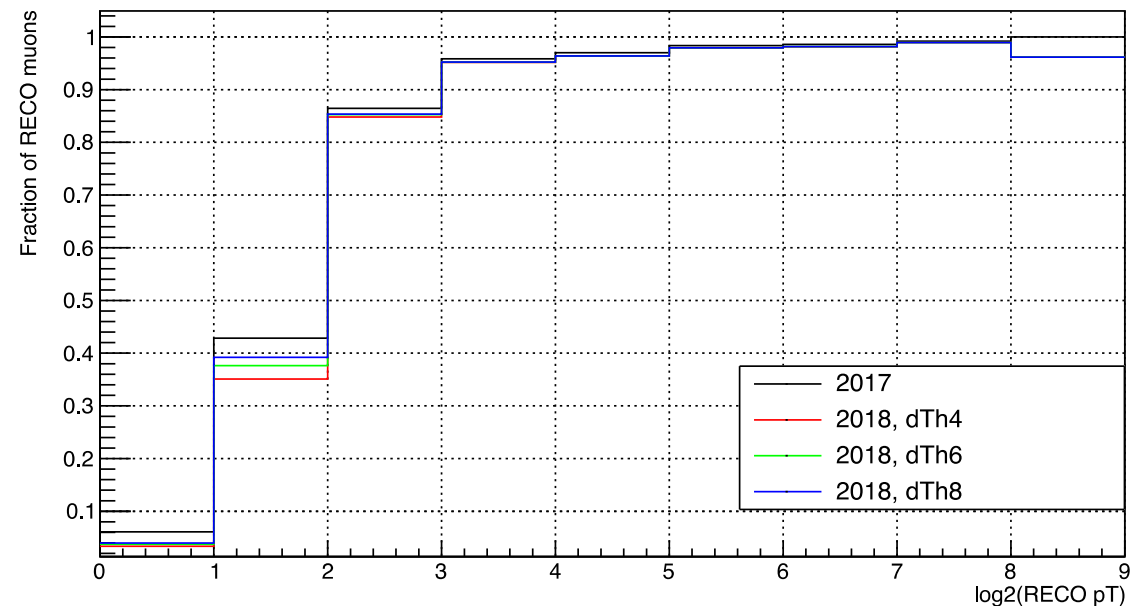
- $\Delta\theta$ = 4 has similar affect on efficiency as SingleMu
- Efficiency loss(~4%) at pT > 256 GeV (including $\mathcal{O}$(TeV) muons) is tolerable

DoubleMu Inclusive: Rate
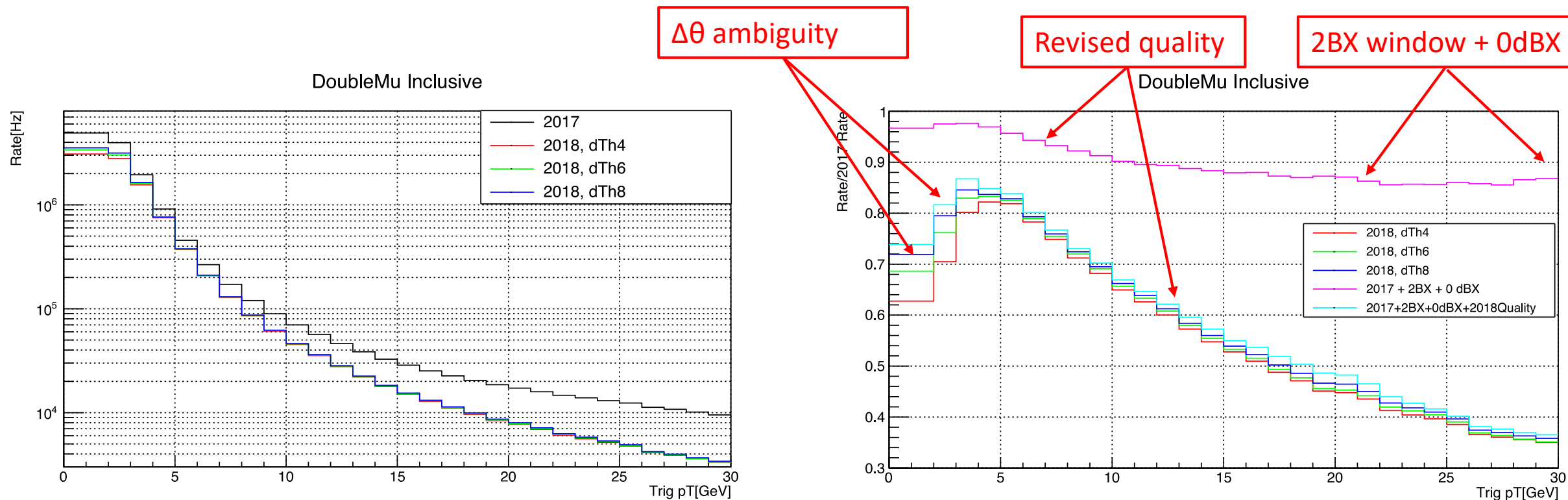
- $\Delta\theta = 4$ gives 58% rate reduction without efficiency loss in DoubleMu quality
- Revised map of mode to quality contributes most to rate reduction (mode 9 ⟵→ mode 12)

MuOpen Inclusive: Efficiency

MuOpen Inclusive: IsRecoMatch && BX0
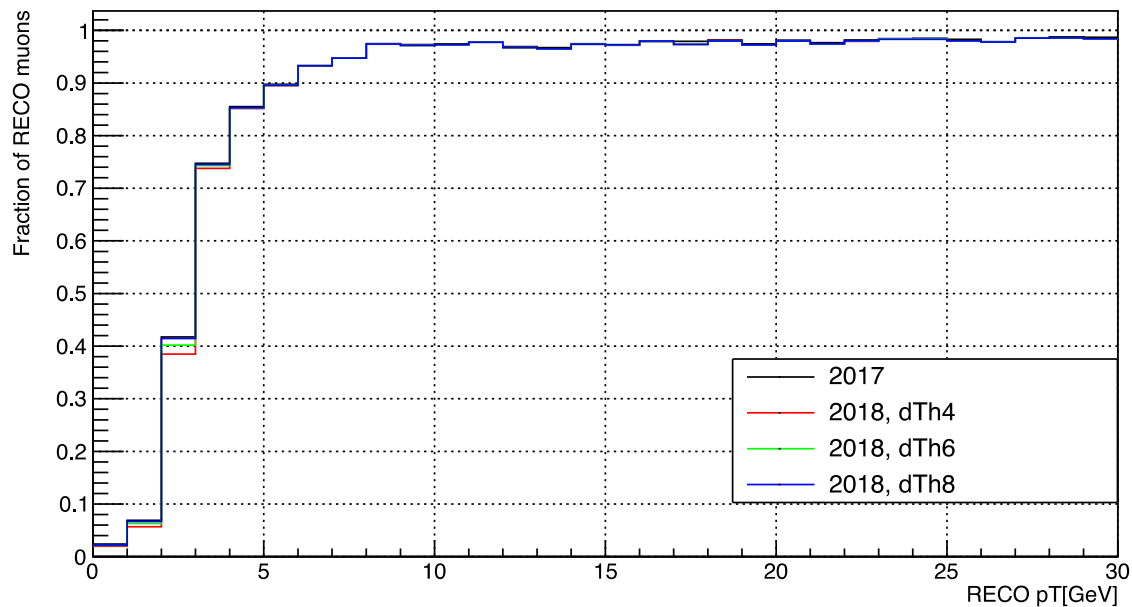
MuOpen Inclusive: IsRecoMatch && BX0
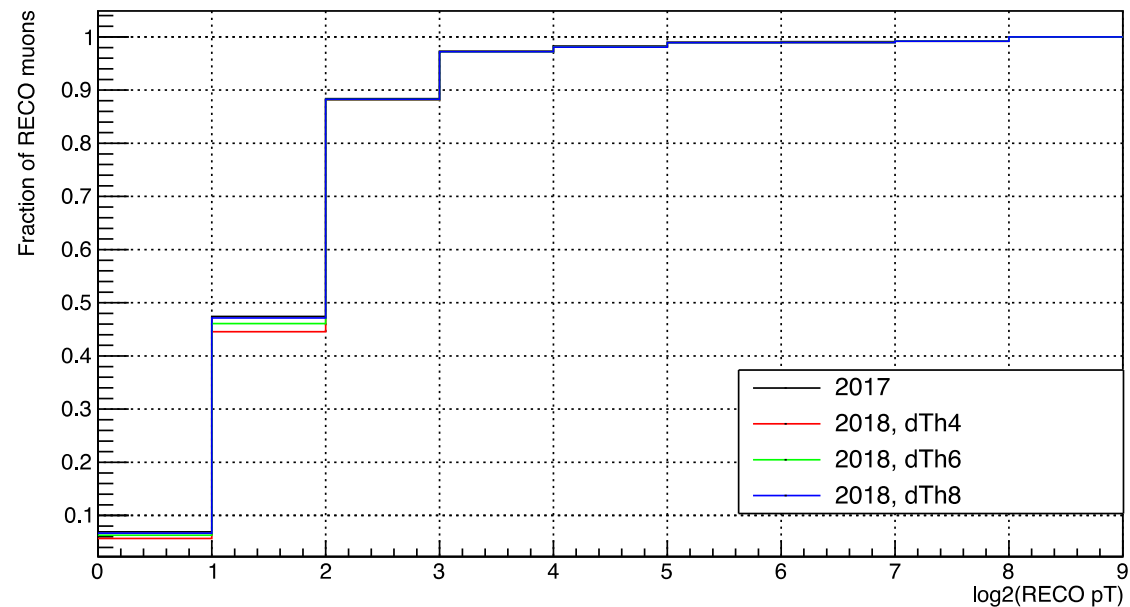
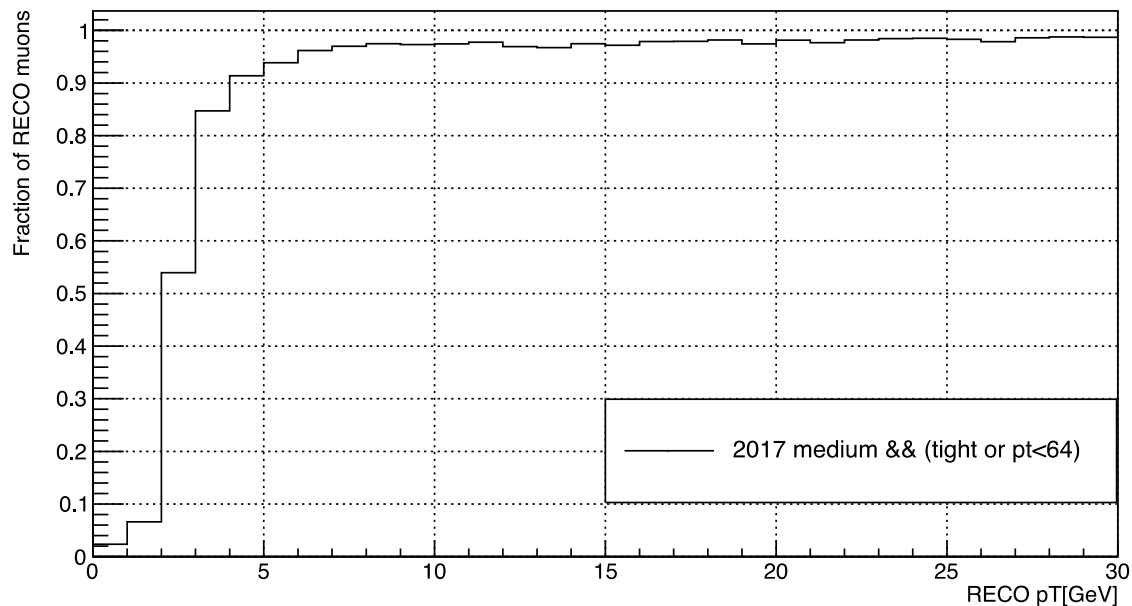- Overall efficiency agrees well with 2017

MuOpen Inclusive: Rate

MuOpen Inclusive

MuOpen Inclusive

Δθ ambiguity

2BX window + 0dBX
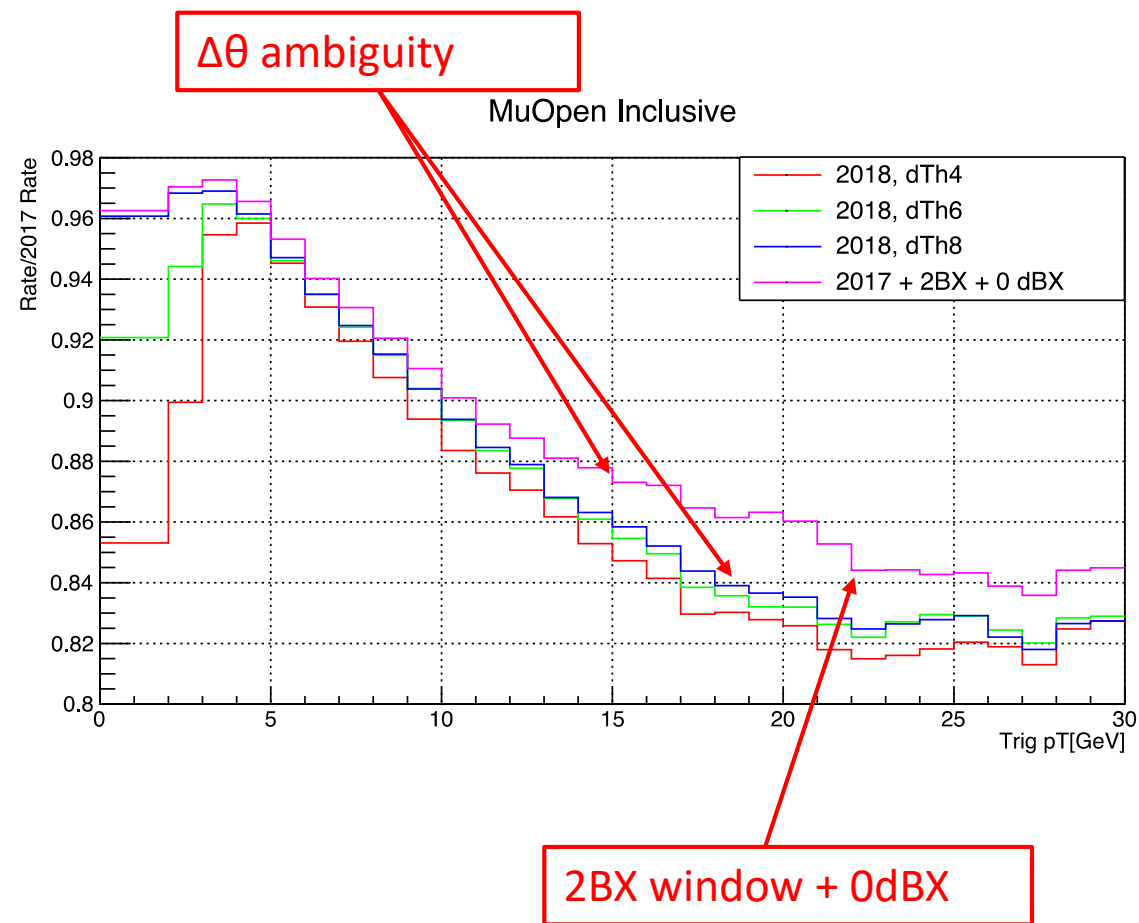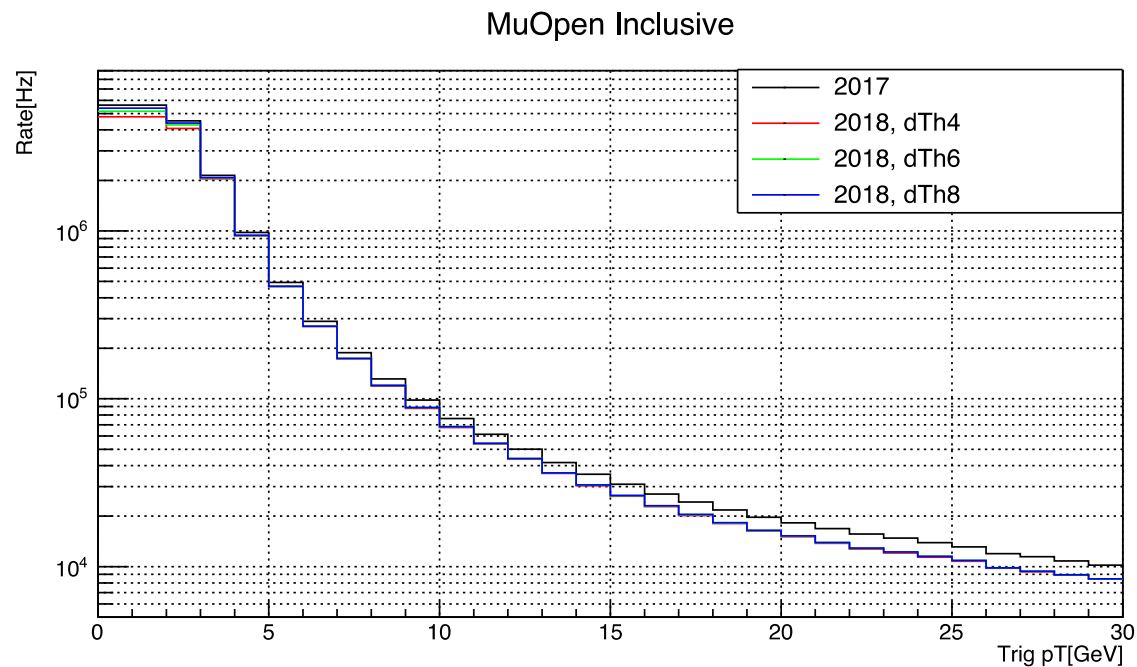
- Δθ = 4 gives 18% rate reduction without efficiency loss overall

Summary

- 2018 EMTF emulator changes show rate reductions with similar efficiency performance to 2017 for all muon quality
  - DoubleMu quality has the most rate reduction due to revised map to modes (mode 9 ←→ mode 12)
- Firmware is ready
  - Implement changes in next weeks pending a fix to EMTF O2O

Back Up
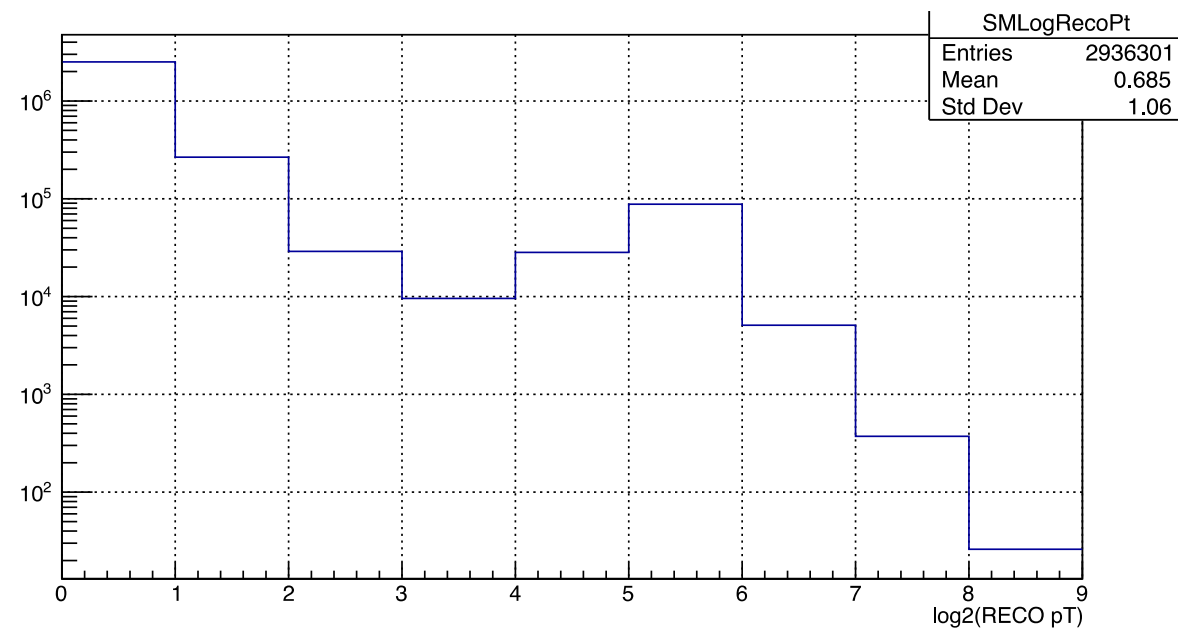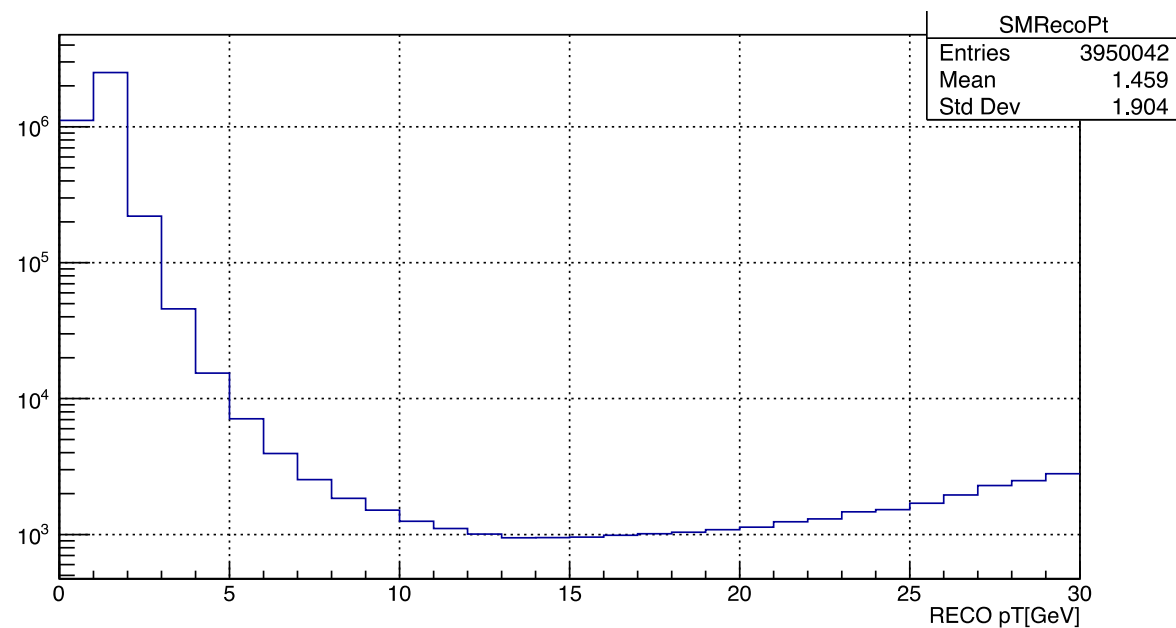
weishi@rice.edu

RECO pT

MuOpen Inclusive: Efficiency
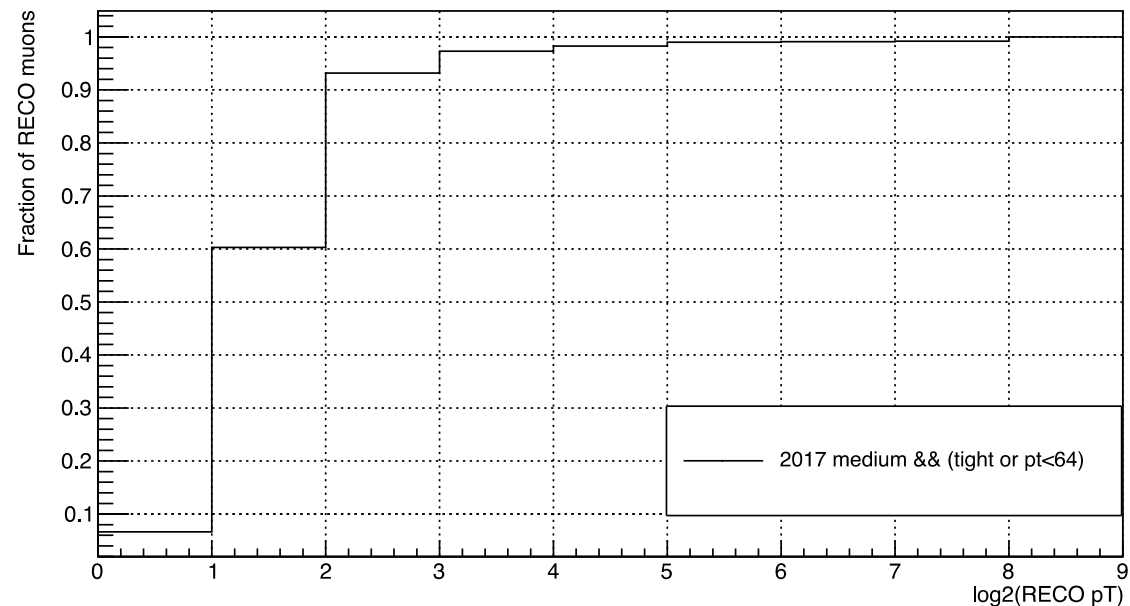
- Require ID
  - pT<64 GeV: medium; pT>64 GeV: tight

MuOpen Inclusive: Efficiency

MuOpen Inclusive: IsRecoMatch && BX0
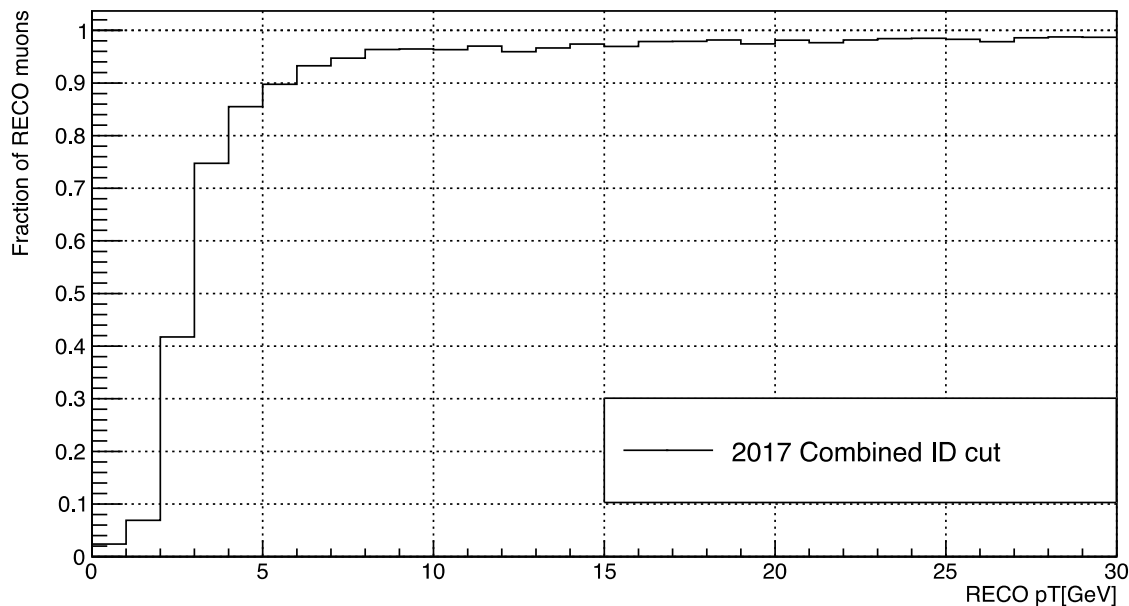
MuOpen Inclusive: IsRecoMatch && BX0
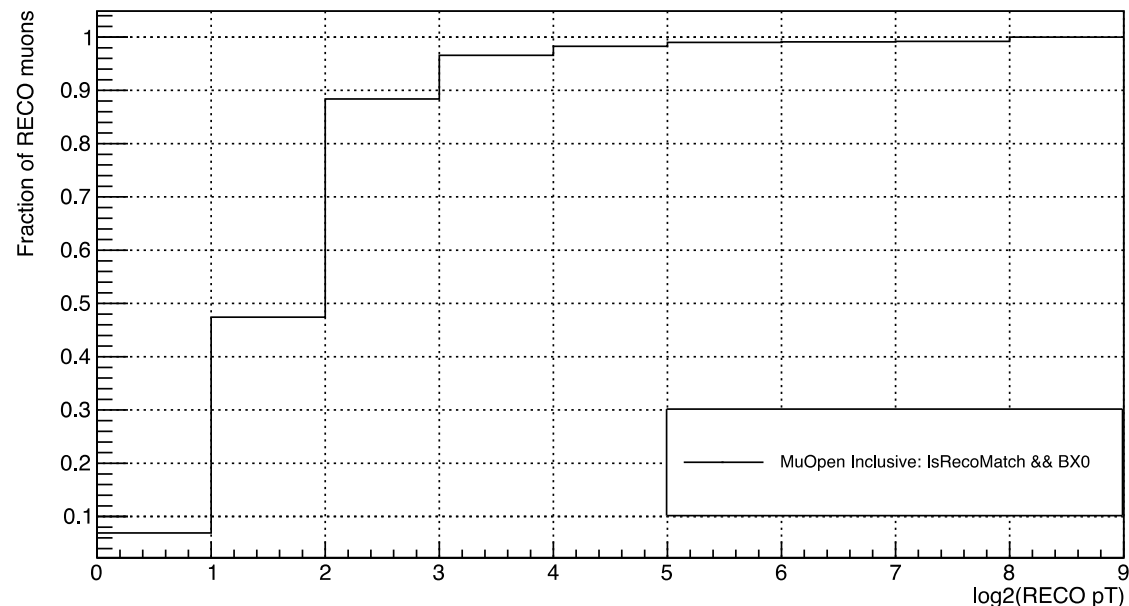
- Require ID
  - pT < 16 GeV: loose && soft or medium
  - 16 < pT < 64 GeV: medium
  - pT > 64 GeV: tight

Muon Quality

- SingleMu (Q>=12)
  - EMTF mode 15, 14, 13, 11

- DoubleMu (Q>=8)
  - EMTF mode 12, 10, 7
  - EMTF mode 15, 14, 13, 11

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

2017 Emulator
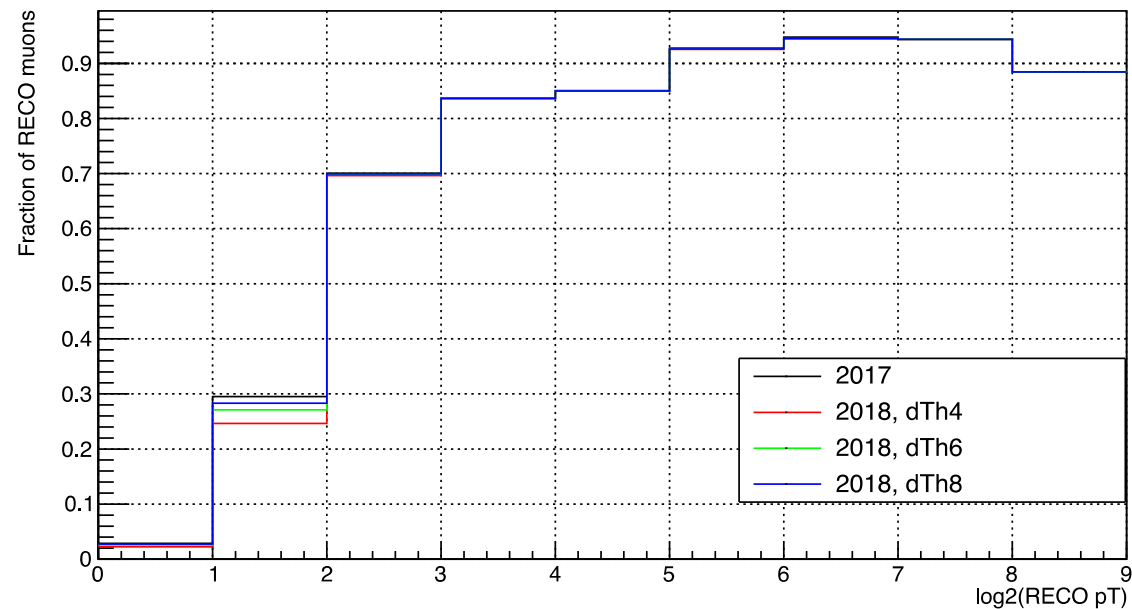
- SingleMu Quality (Q>=12)
  - EMTF mode 15, 14, 13, 11

- DoubleMu Quality (Q>=8)
  - EMTF mode 9, 10, 7
  - EMTF mode 15, 14, 13, 11

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

2018 Emulator
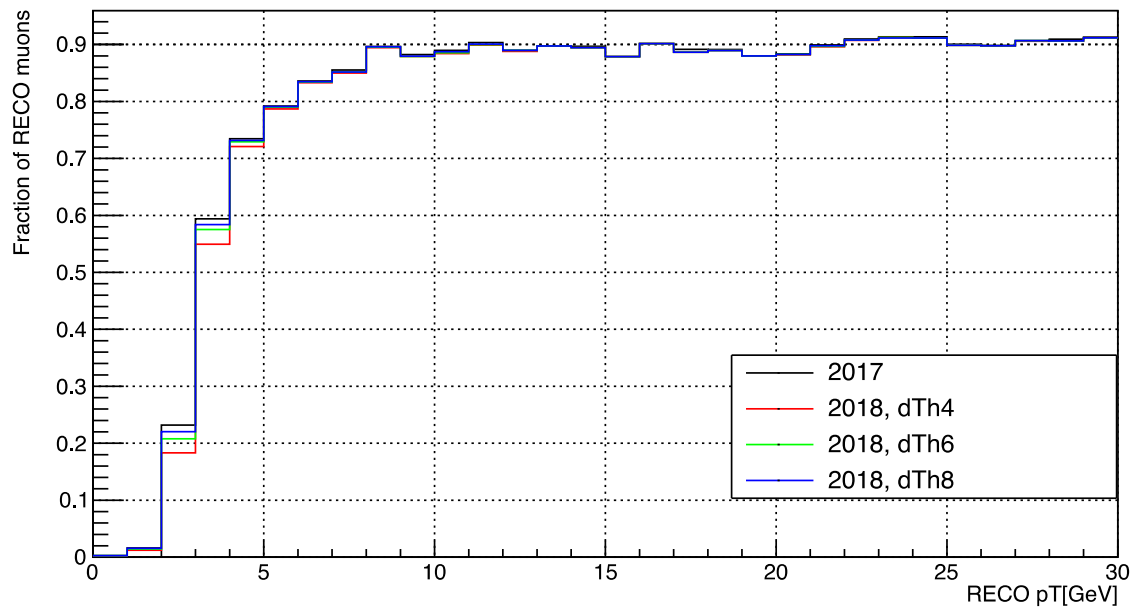
SingleMu: plateau efficiency
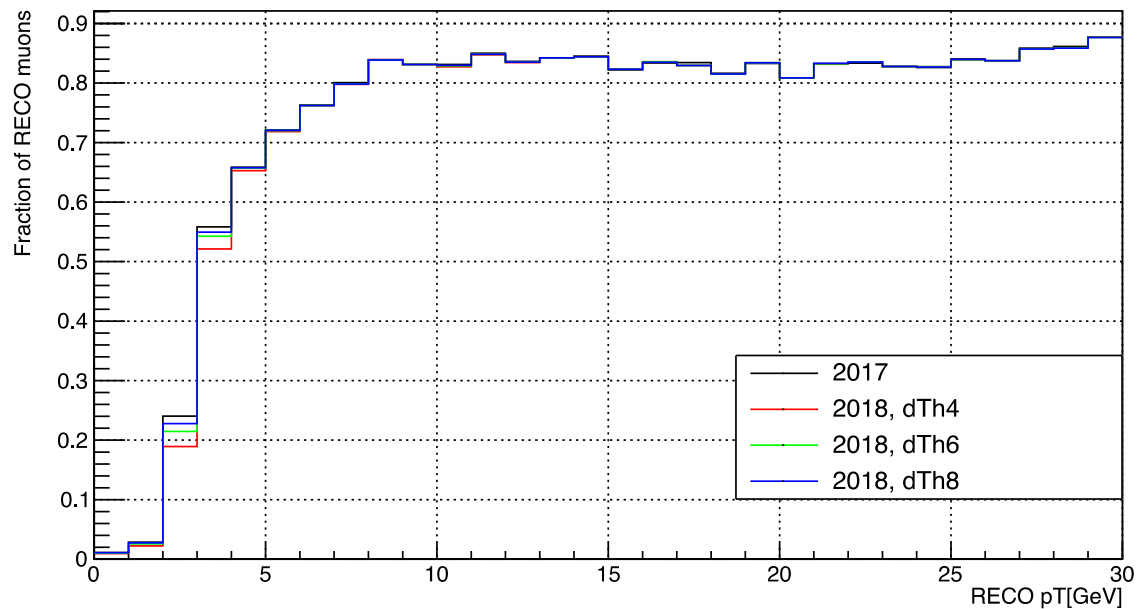
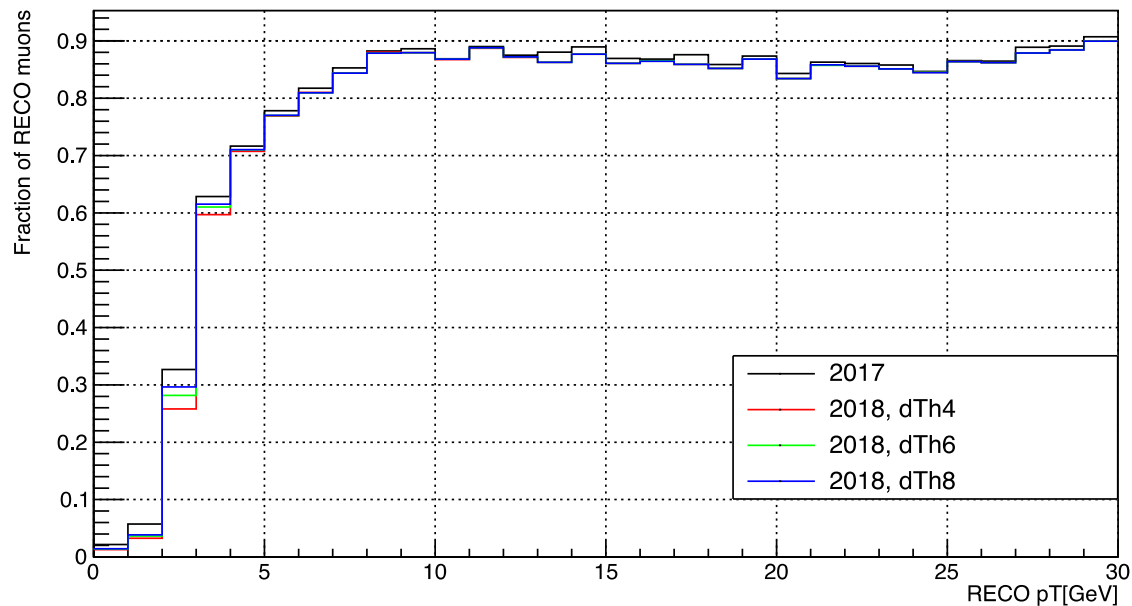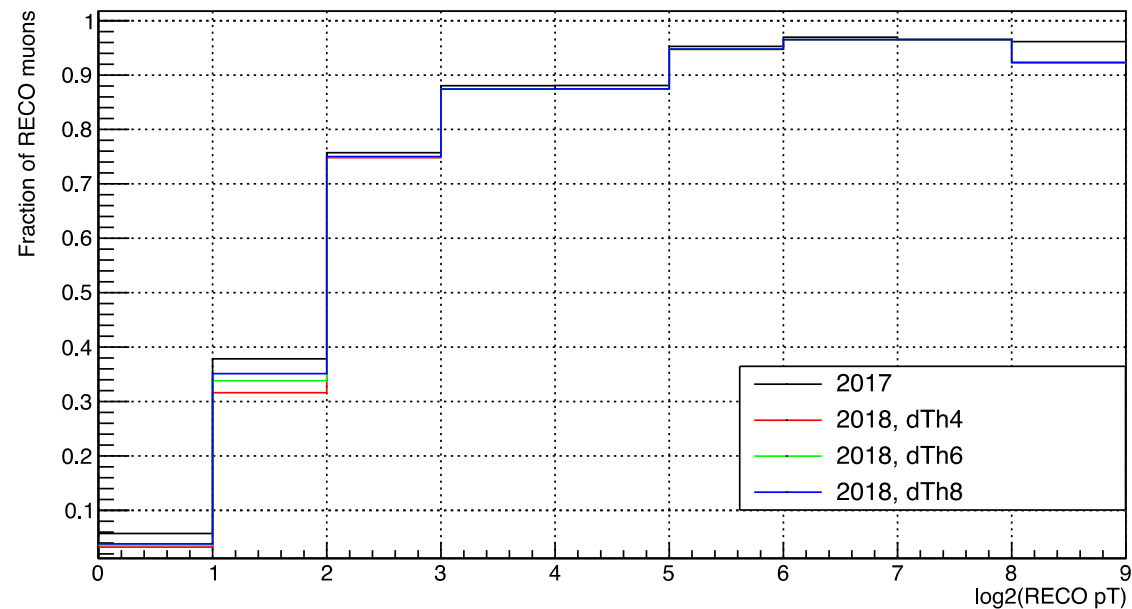# SingleMu: unique match efficiency
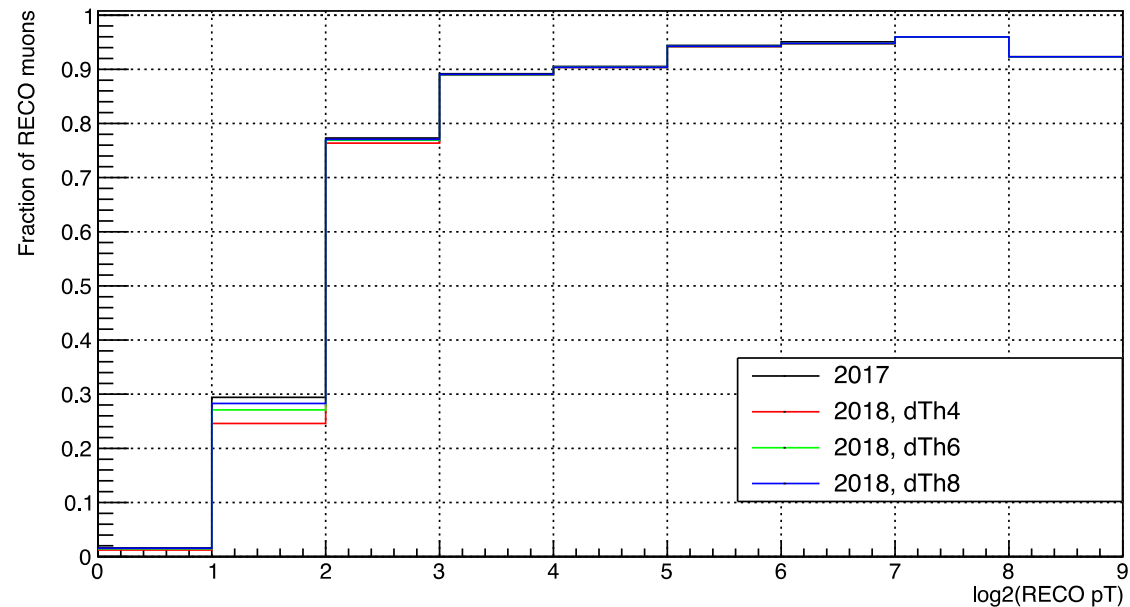
DoubleMu Inclusive: plateau efficiency

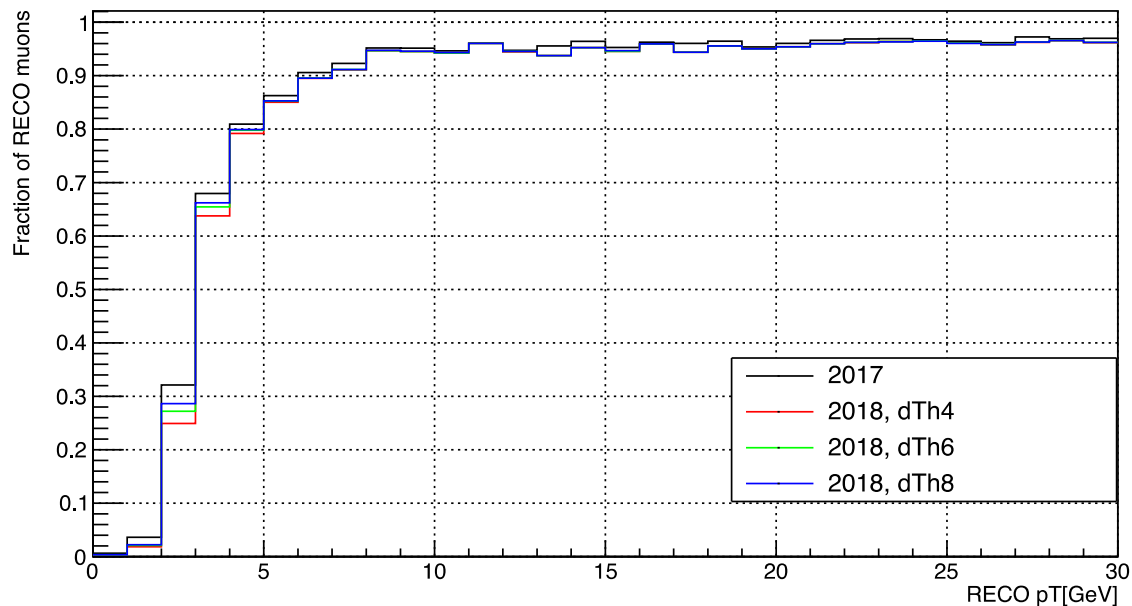DoubleMu Inclusive: IsRecoMatch && BX0 && Plateau
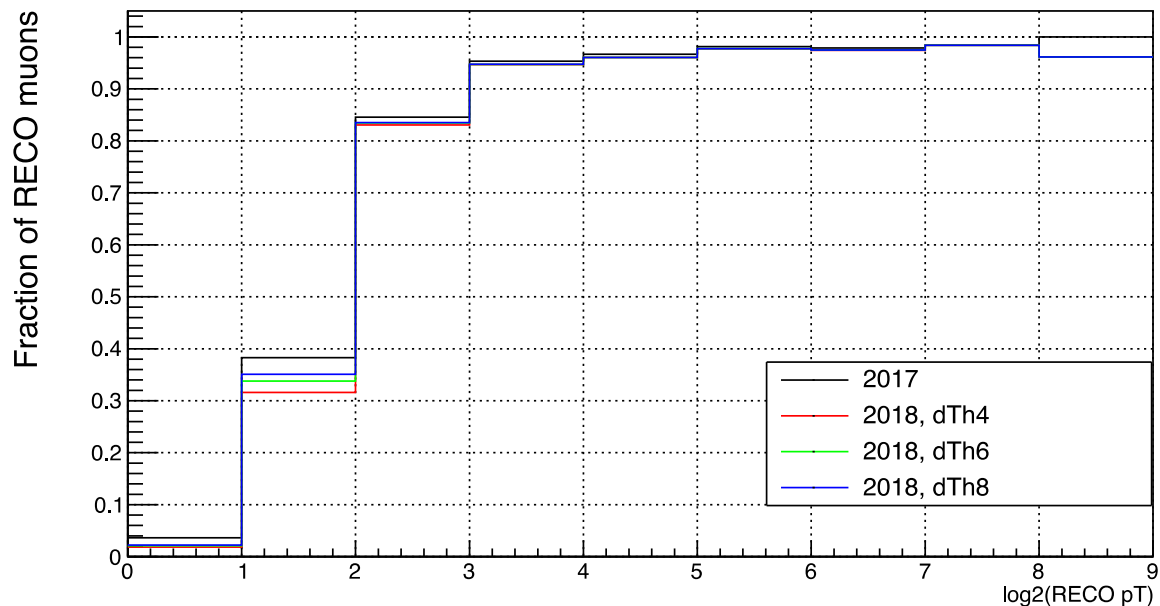

DoubleMu Inclusive: IsRecoMatch && BX0 && Plateau

DoubleMu inclusive: unique match efficiency

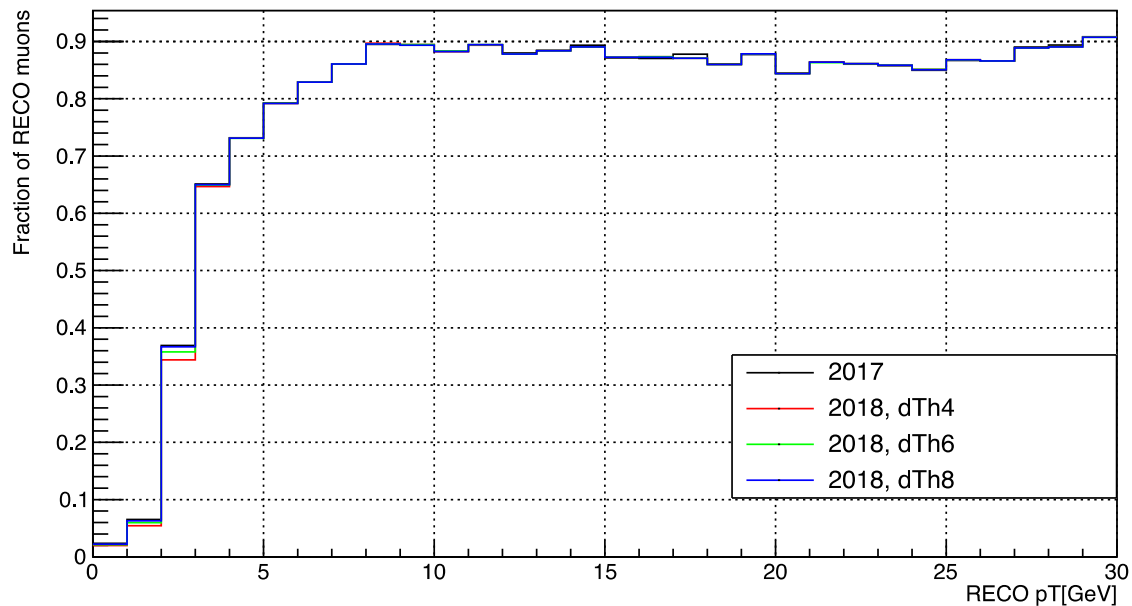DoubleMu Inclusive: IsRecoMatch && BX0 && Unique

DoubleMu Inclusive: IsRecoMatch && BX0 && Unique

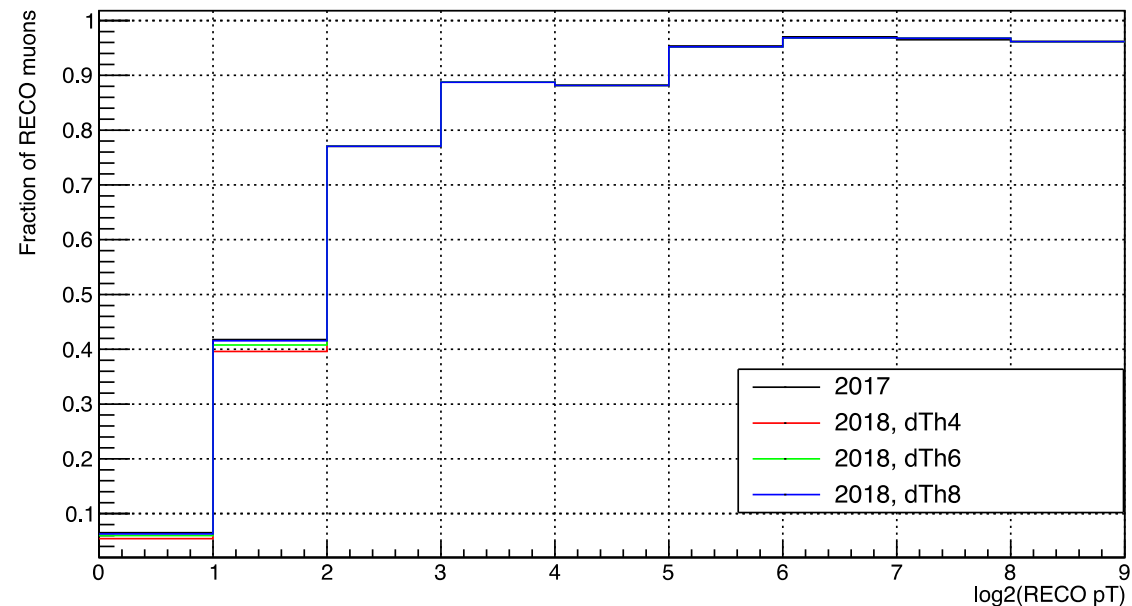2017
2018, dTh4
2018, dTh6
2018, dTh8

MuOpen Inclusive: plateau efficiency

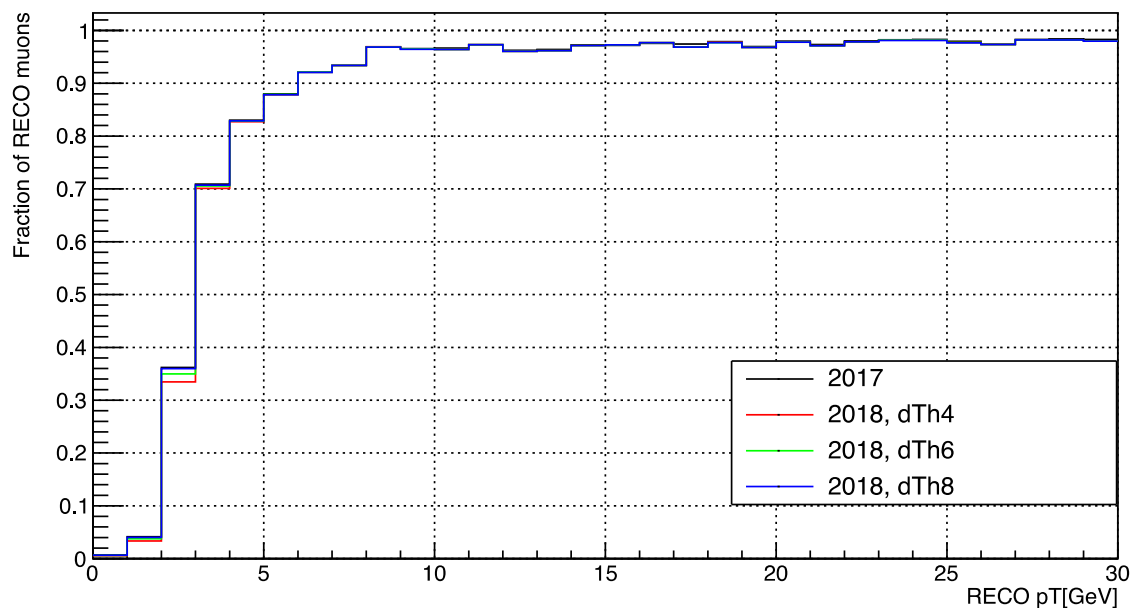MuOpen Inclusive: IsRecoMatch && BX0 && Plateau

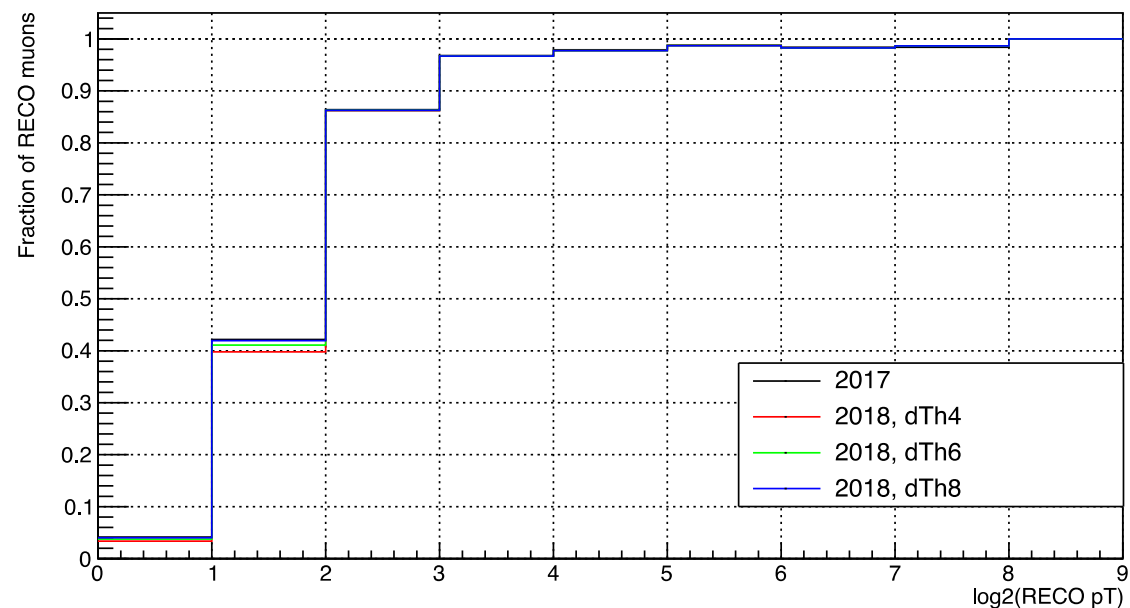MuOpen Inclusive: IsRecoMatch && BX0 && Plateau

MuOpen Inclusive: unique match efficiency

MuOpen Inclusive: IsRecoMatch && BX0 && Unique

MuOpen Inclusive: IsRecoMatch && BX0 && Unique

EMTF track modes vs Stations

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

Data Files

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

- 2017
  - NTuple_SingleMuon_FlatNtuple_Run_306154_2018_05_07_SingleMu_2017_emul.root
  - NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_05_07_ZB1_2017_emul.root
  - NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_05_07_ZB1_2017_emul_dBX.root

- 2018
  - NTuple_SingleMuon_FlatNtuple_Run_306154_2018_05_07_SingleMu_2018_emul_dTh4.root
    NTuple_SingleMuon_FlatNtuple_Run_306154_2018_05_07_SingleMu_2018_emul_dTh6.root
    NTuple_SingleMuon_FlatNtuple_Run_306154_2018_05_07_SingleMu_2018_emul_dTh8.root
  - NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_05_07_ZB1_2018_emul_dTh4.root
    NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_05_07_ZB1_2018_emul_dTh6.root
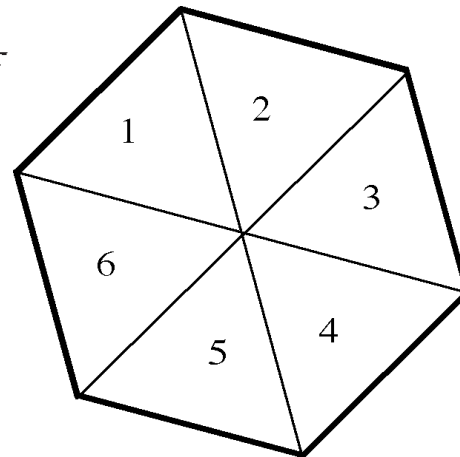   NTuple_ZeroBias1_FlatNtuple_Run_306091_2018_05_07_ZB1_2018_emul_dTh8.root
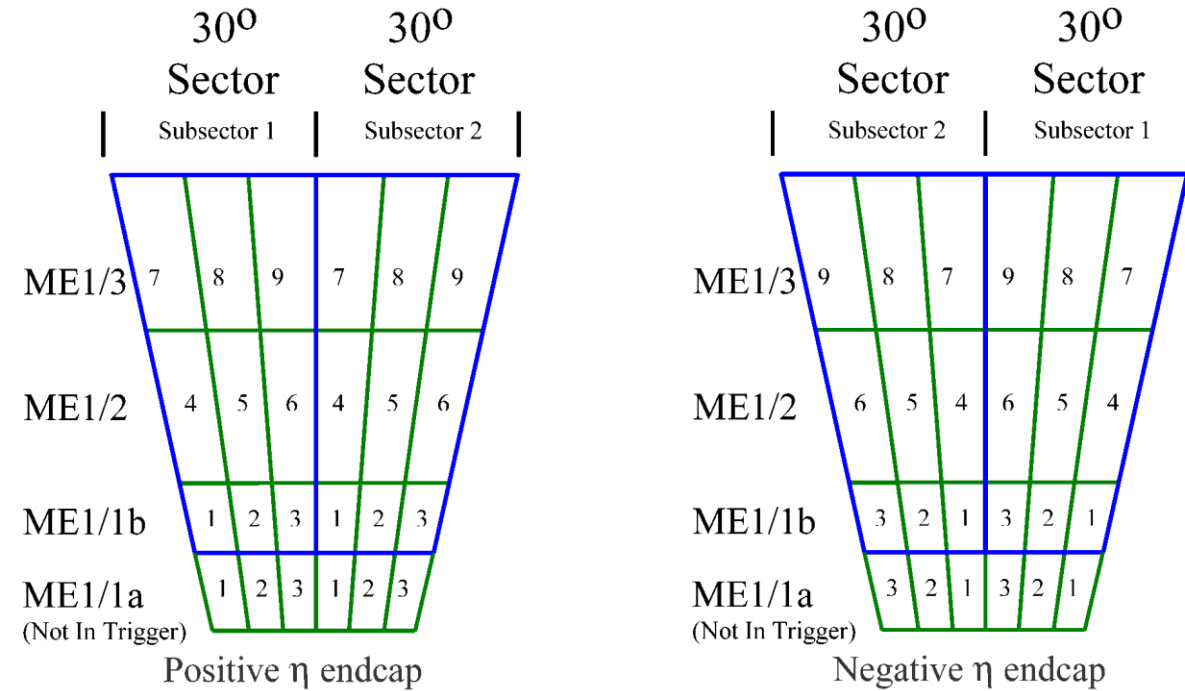
CSC Geometry

Station 1

Station 2, 3, 4

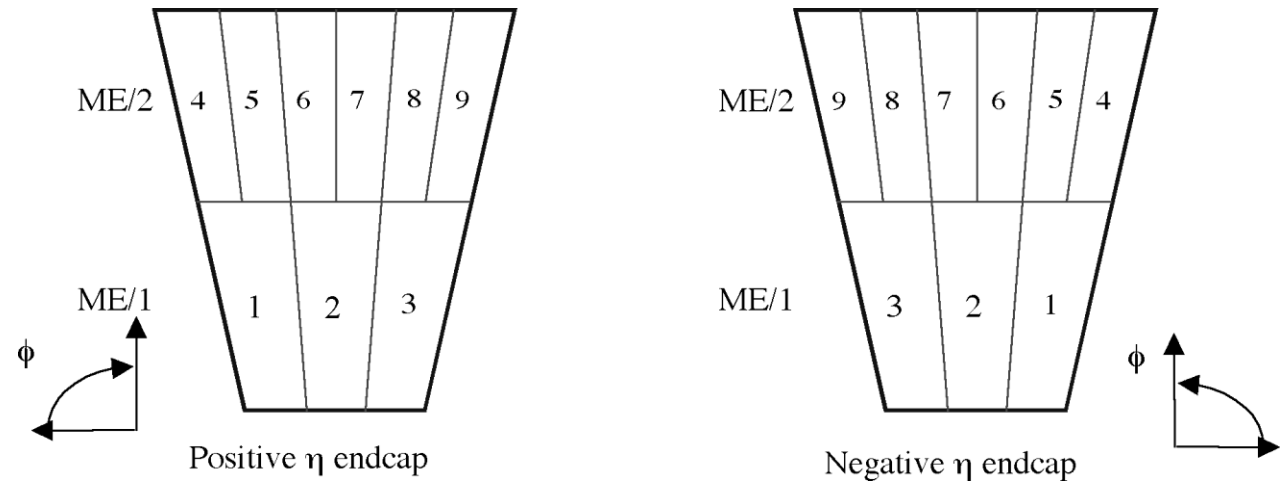weishi@rice.edu
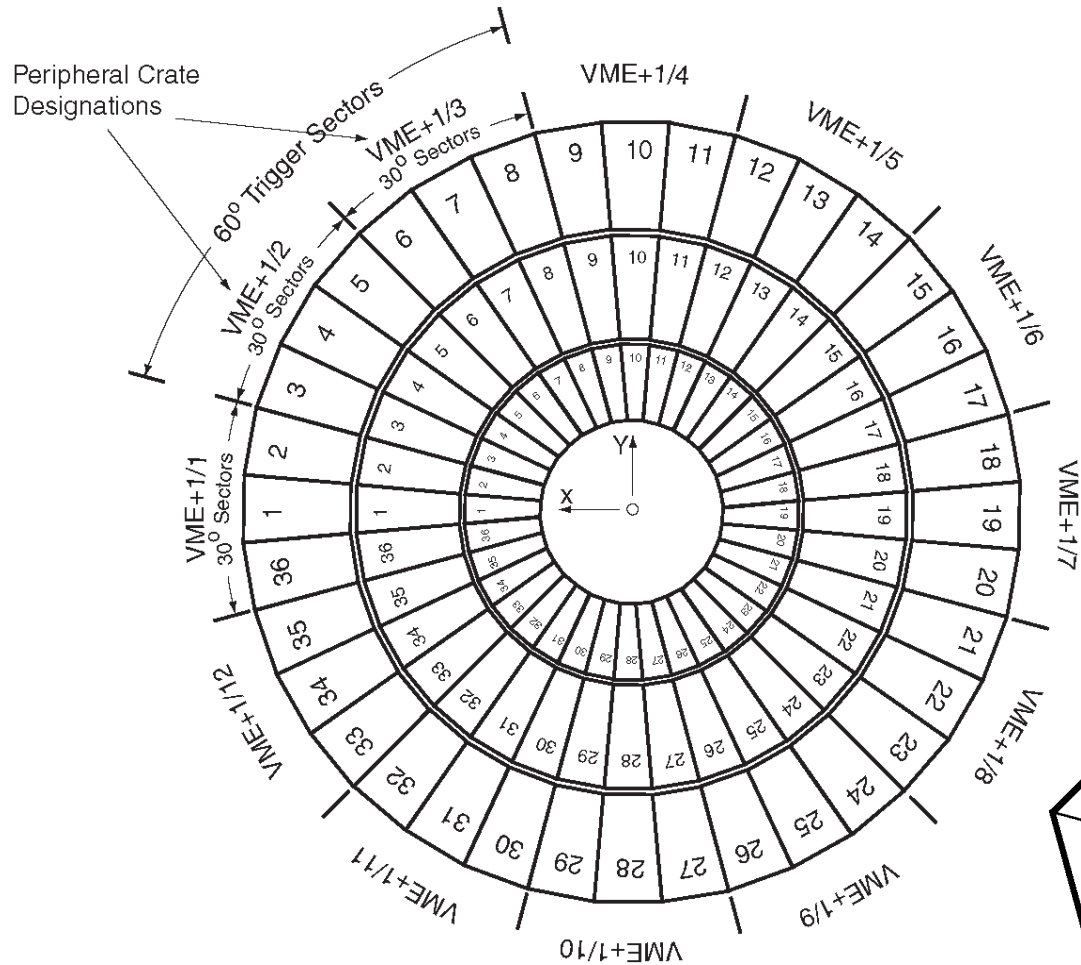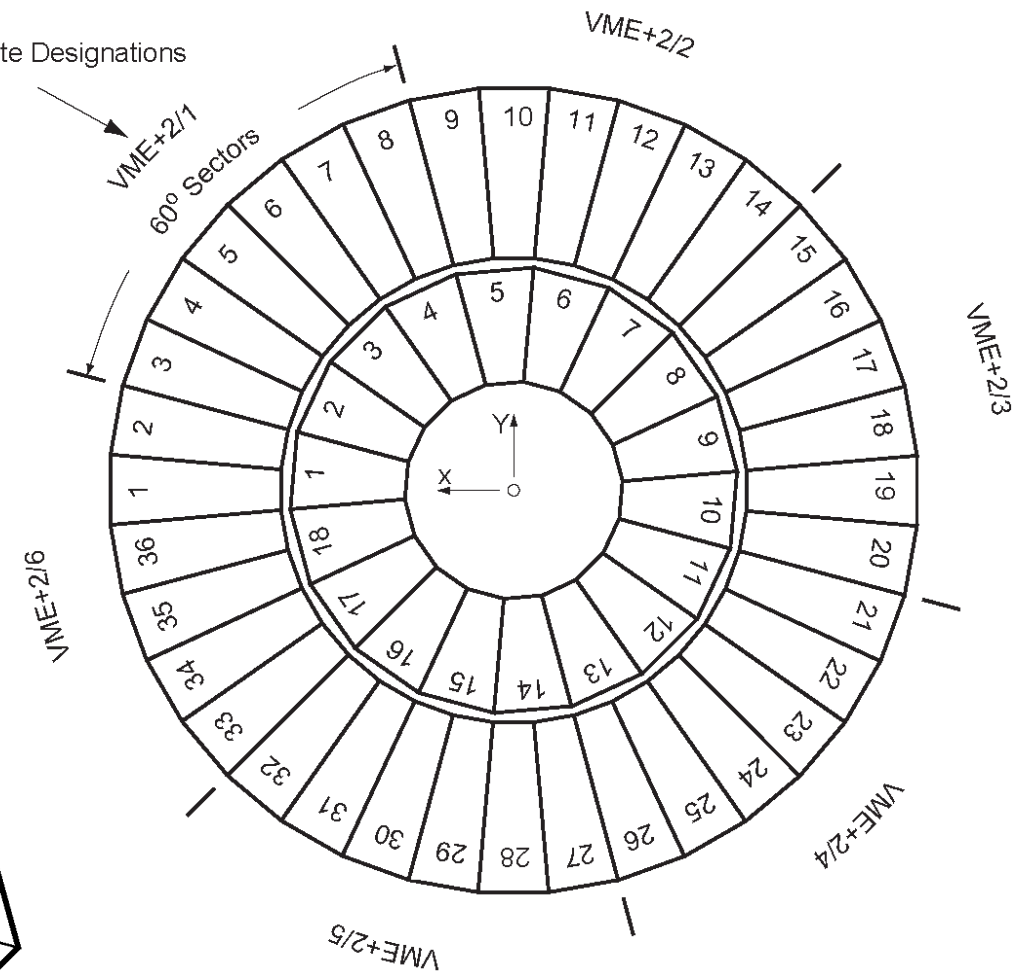
CSCs in a trigger sector

Station 1

Station 2, 3, 4