Trigger Rates & Efficiency at the CSC/DT Overlap

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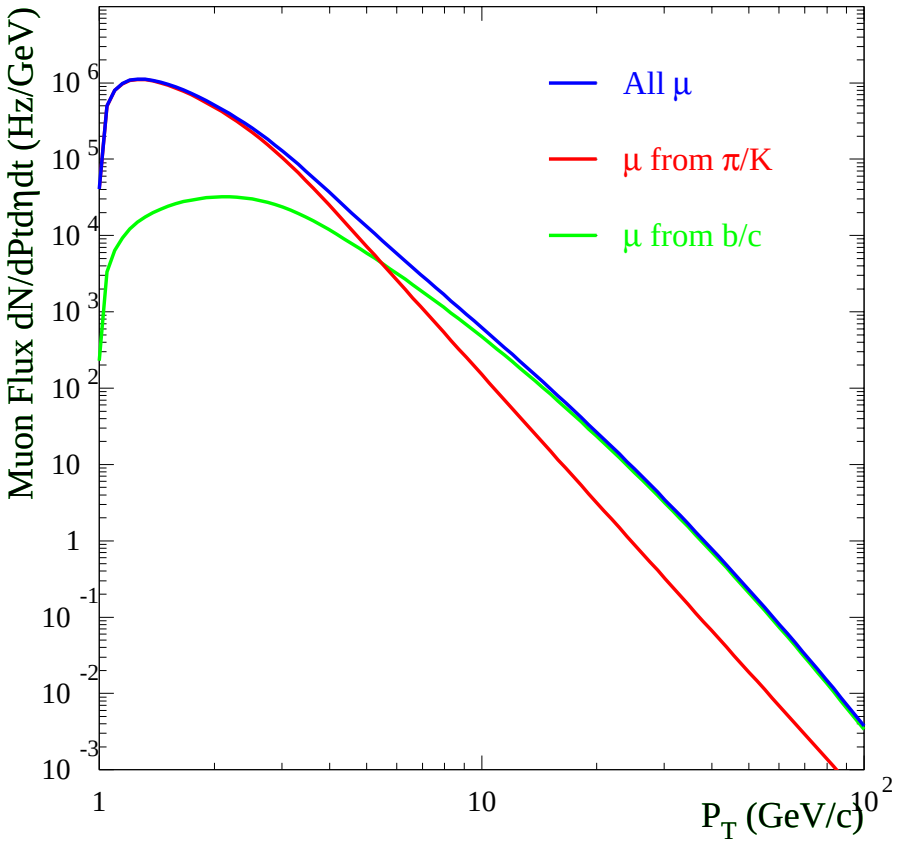
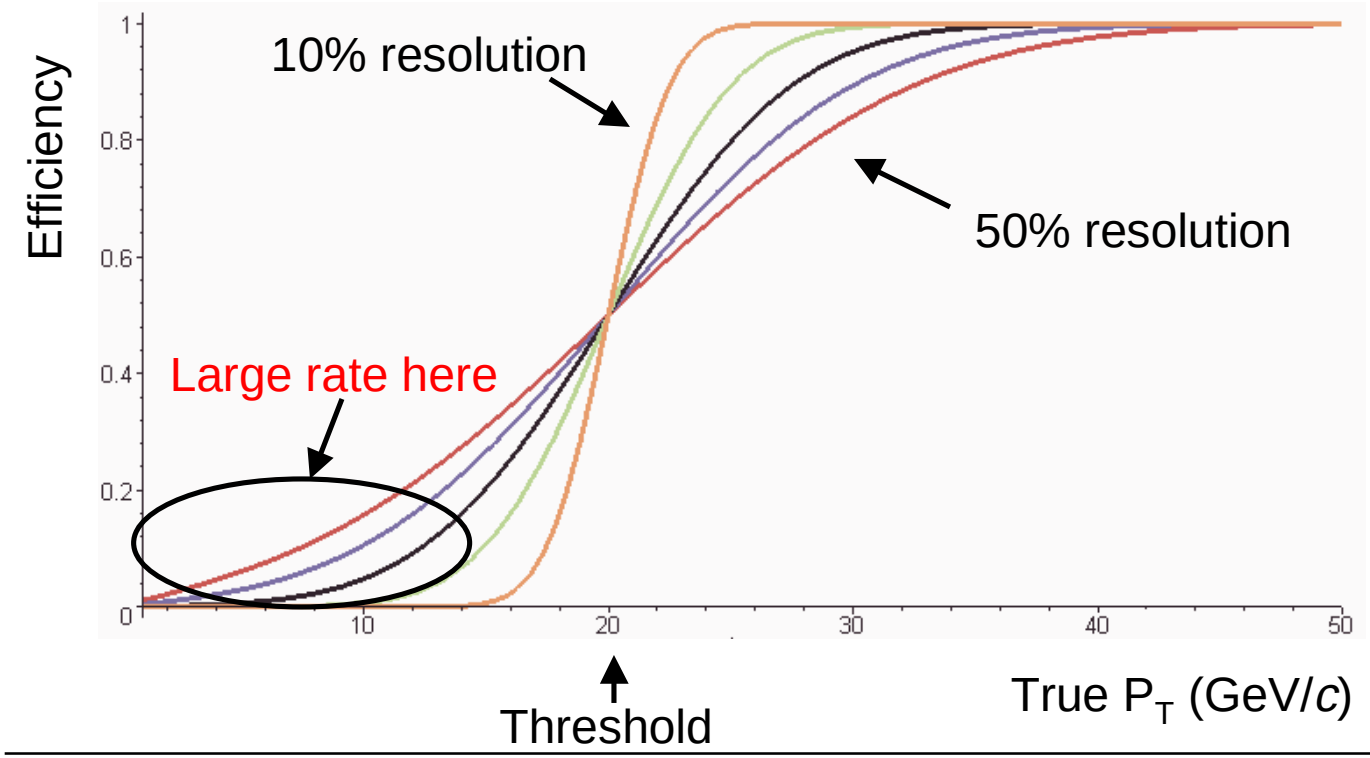
Estimated Muon Flux



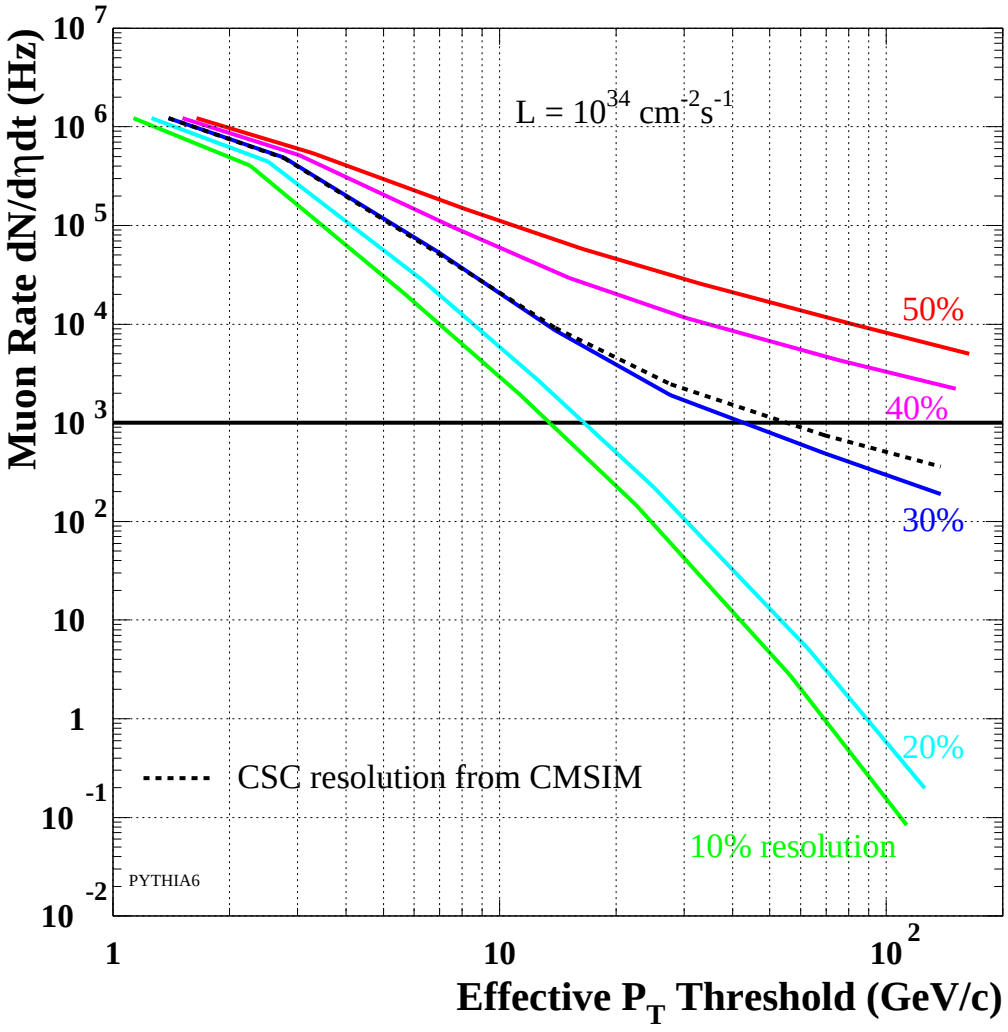
- Estimate muon flux at $L=10^{34}$ from QCD events
  - Parameterization based on Pythia (CMS Note 1997/096)
  - Includes π/K which decay before calorimeter
- Fold in probability to punch through calorimeter in endcap region
  - Determined from CMSIM
- Assume 100% chamber efficiency

Trigger Efficiency Curves

- **Convolute muon flux with trigger efficiency curve to determine trigger rate**
- **Assume Gaussian errors for $1/P_T$ resolution**



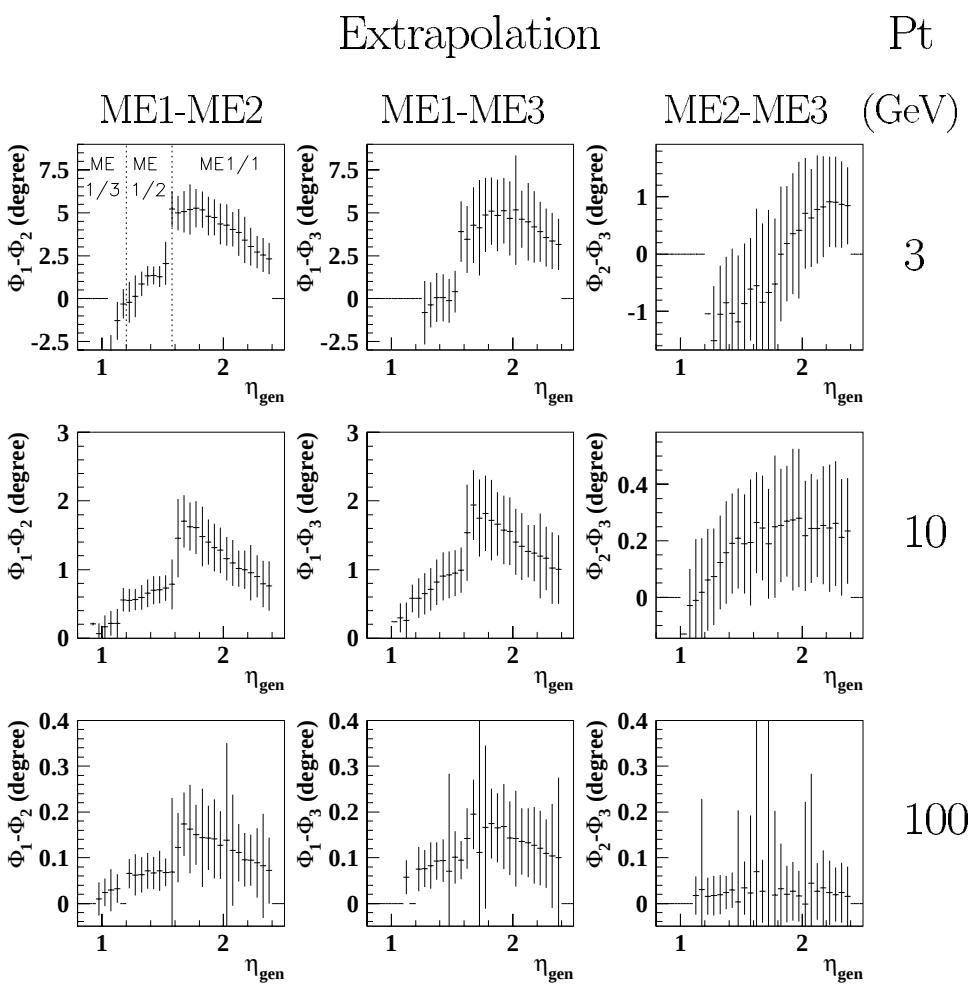
CSC Muon Trigger Rates



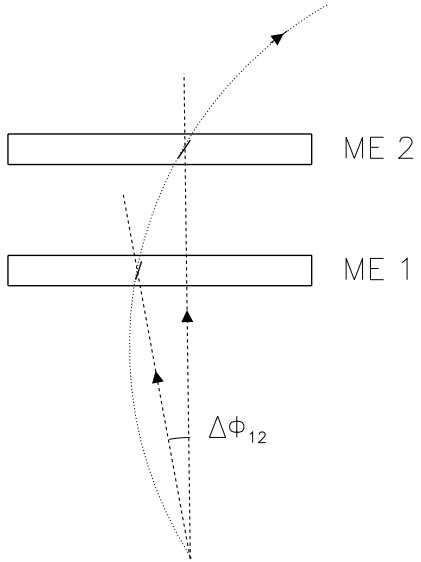
- Single μ rate from Pythia, convoluted with efficiency curve
- Thresholds set for 90% efficiency
- Require rates < 1 kHz per unit rapidity
- Not satisfied for P_T resolution worse than 30%

CMSIM Study of CSC Trigger Resolution

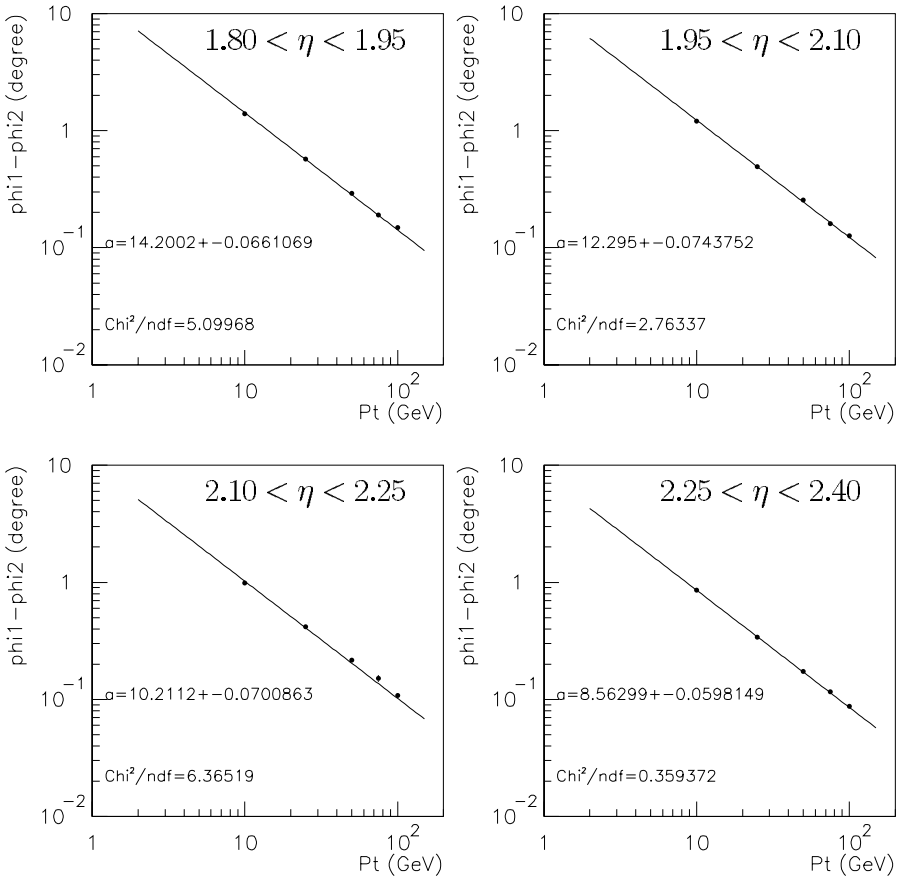
$\Delta\phi$ vs η_{gen} at different Pt



- **Study dependence of $\Delta\varphi$ on η and P_T**
- **φ and η from LCT trigger simulation of single μ's with no backgrounds**



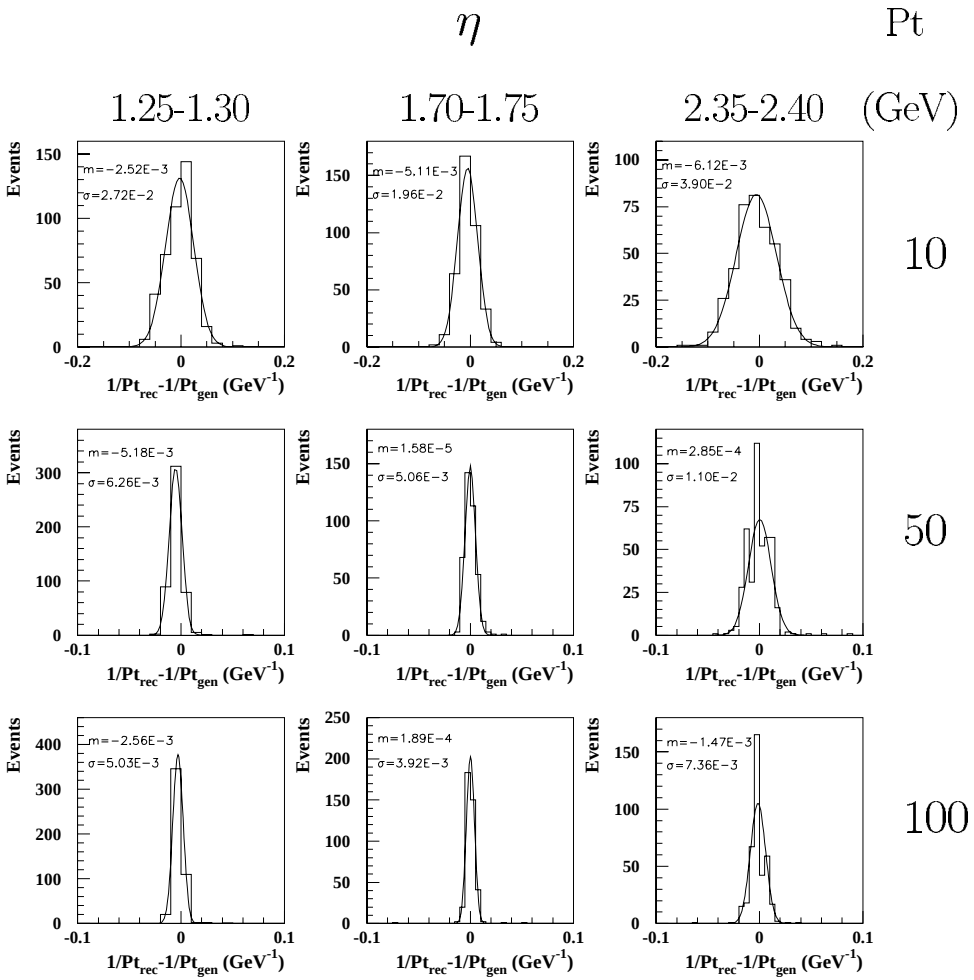
Parameterize $\Delta\varphi$ vs. P_T and η



- Fit to $\Delta\varphi = A(\eta)/ P_T$
- Invert relation to obtain P_T

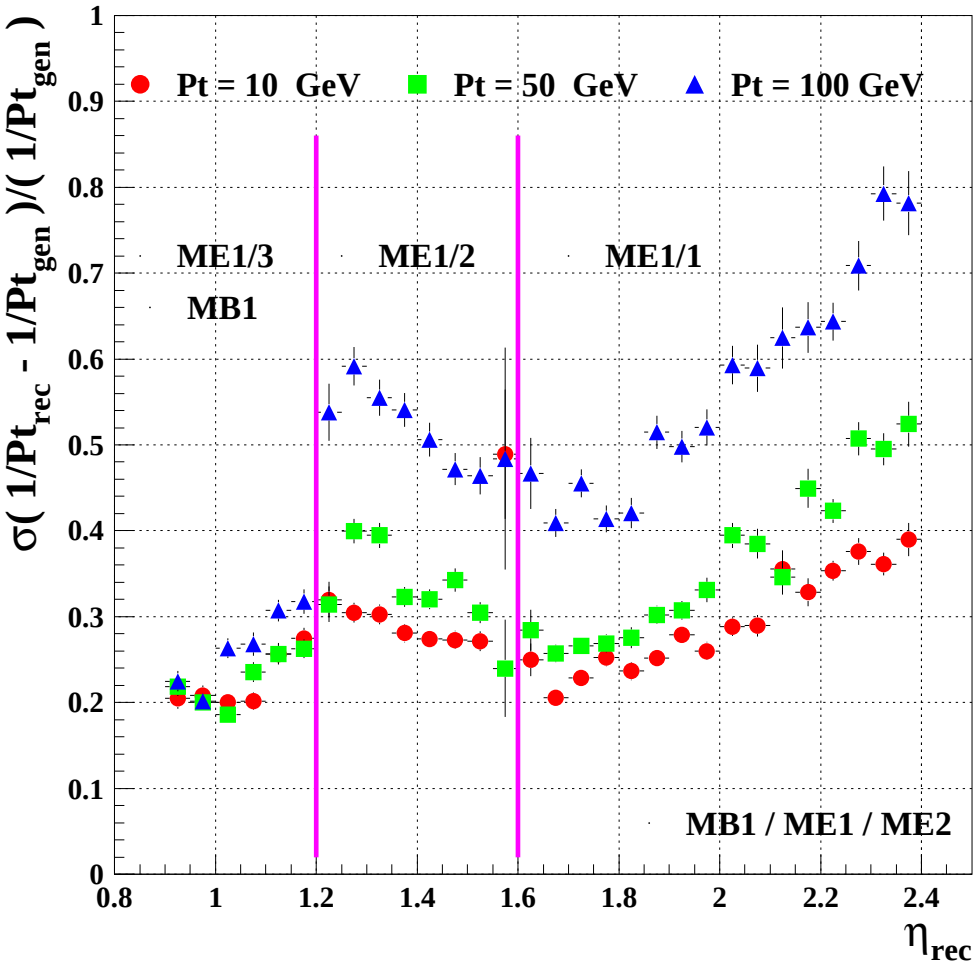
Resolution of $1/P_T$

$\frac{1}{Pt_{rec}} - \frac{1}{Pt_{gen}}$ Distributions



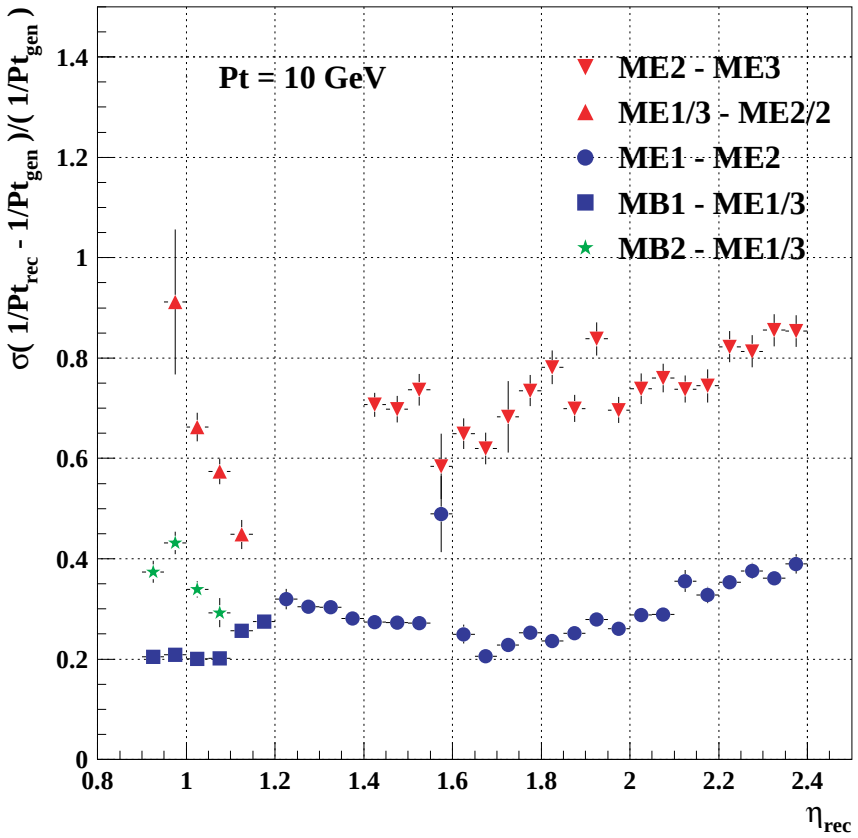
- **Single μ's with no background**
- **Distributions are Gaussian**
- **No significant tails**

Expected P_T Resolution from CSC Track-Finder



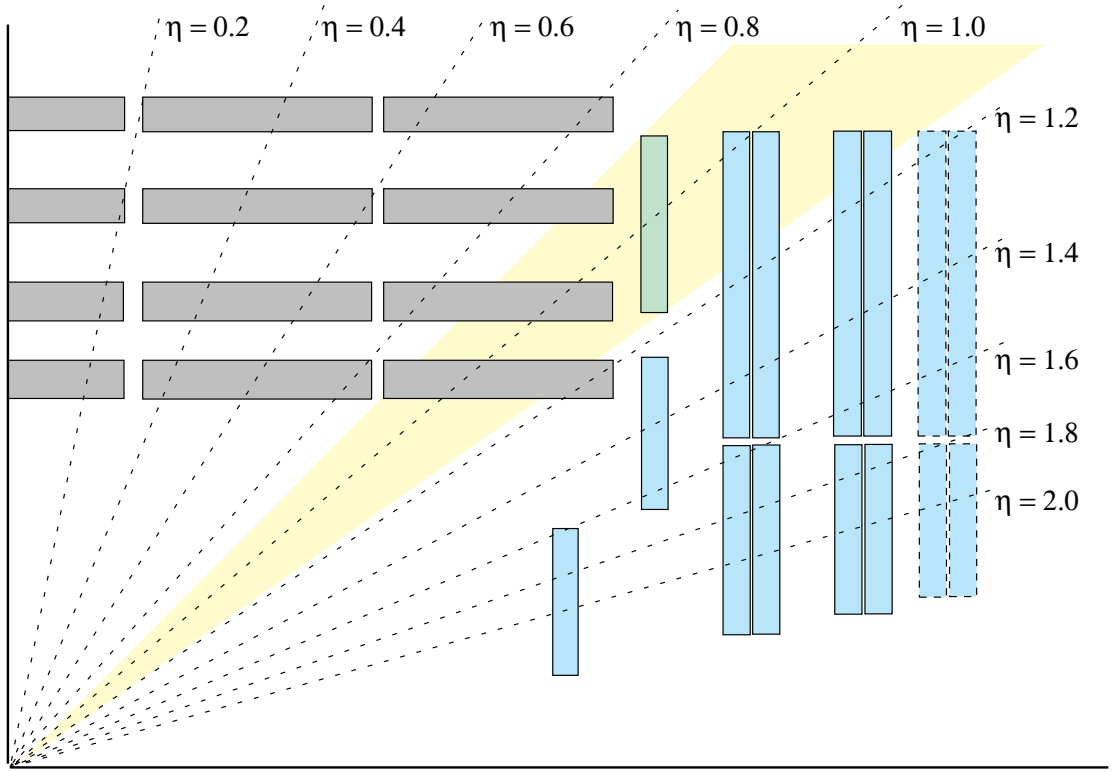
- P_T obtained from $\Delta\varphi$ measured between MB1-ME1 ($0.9<\eta<1.2$) ME1-ME2 ($1.2<\eta<2.4$)
- Resolution ~30% at low P_T
- Expected to be improved as Track-Finder design evolves

P_T Resolution with & without Measurement in MB1 or ME1



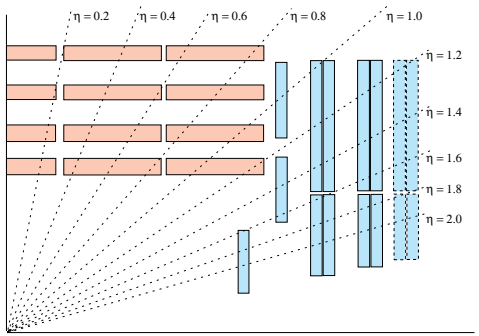
- P_T Resolution ~70% without MB1 or MB2 in overlap region, or without ME1 in endcap
- Cannot satisfy single μ rate requirement without station 1

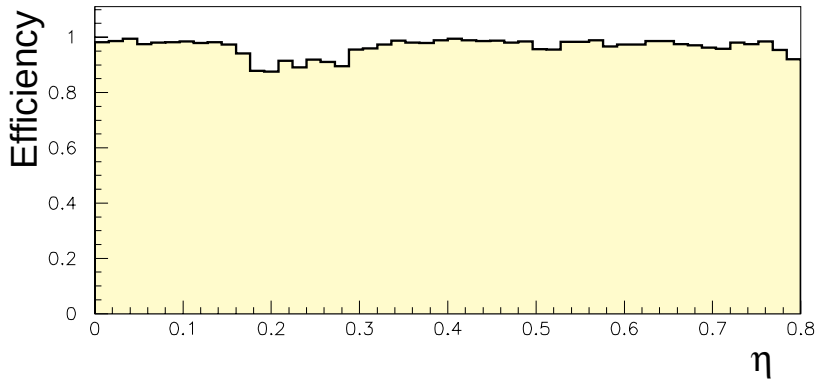
Efficiency in Overlap Region

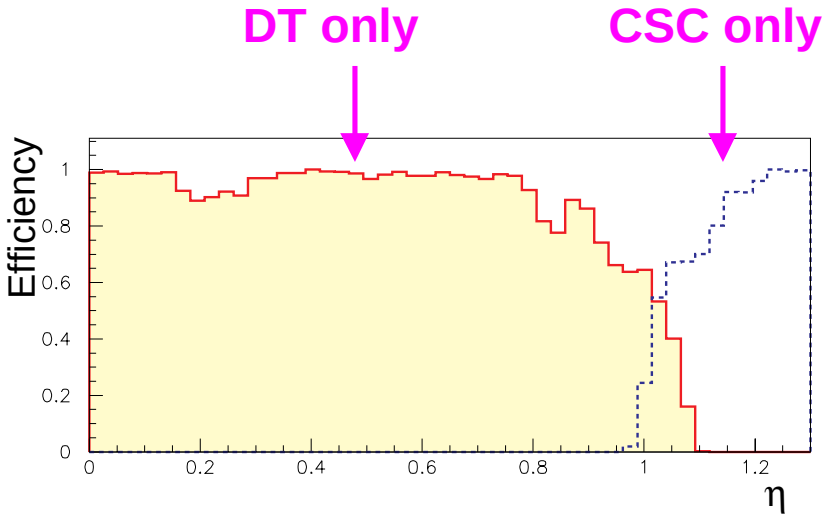


- **Barrel and endcap trigger systems share information in overlap region**
- **Either system can identify muons in this region, but sharp η cut will prevent duplication**

Overlap Region: No Sharing

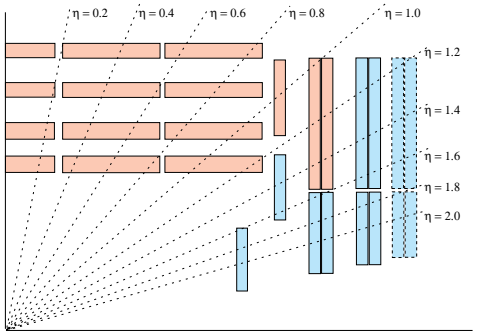


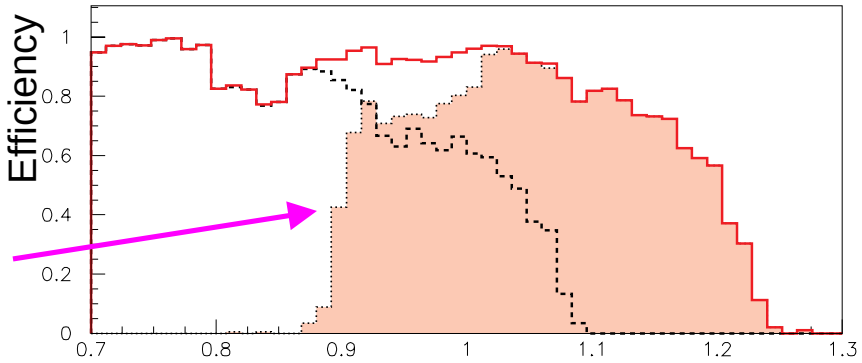




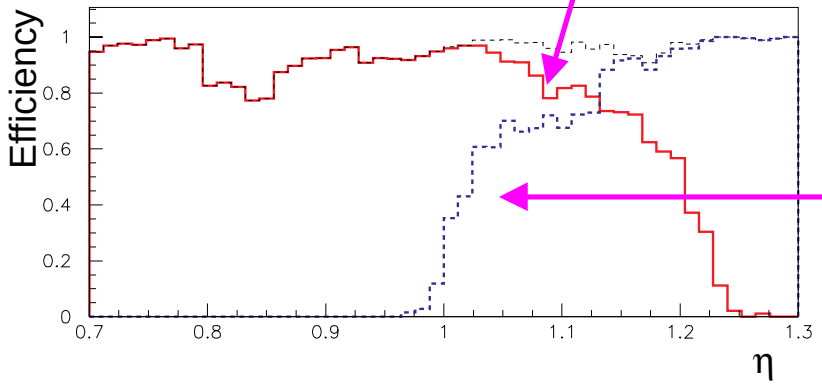
- CMSIM study performed by Vienna
- Poor efficiency around η=1 without sharing

Overlap Region: Barrel+ME1/3+ME2/2





Extended DT coverage



CSC coverage without DT

- **Require DT and CSC information in overlap region for efficient coverage**
- **Will define a sharp η boundary to avoid duplication**

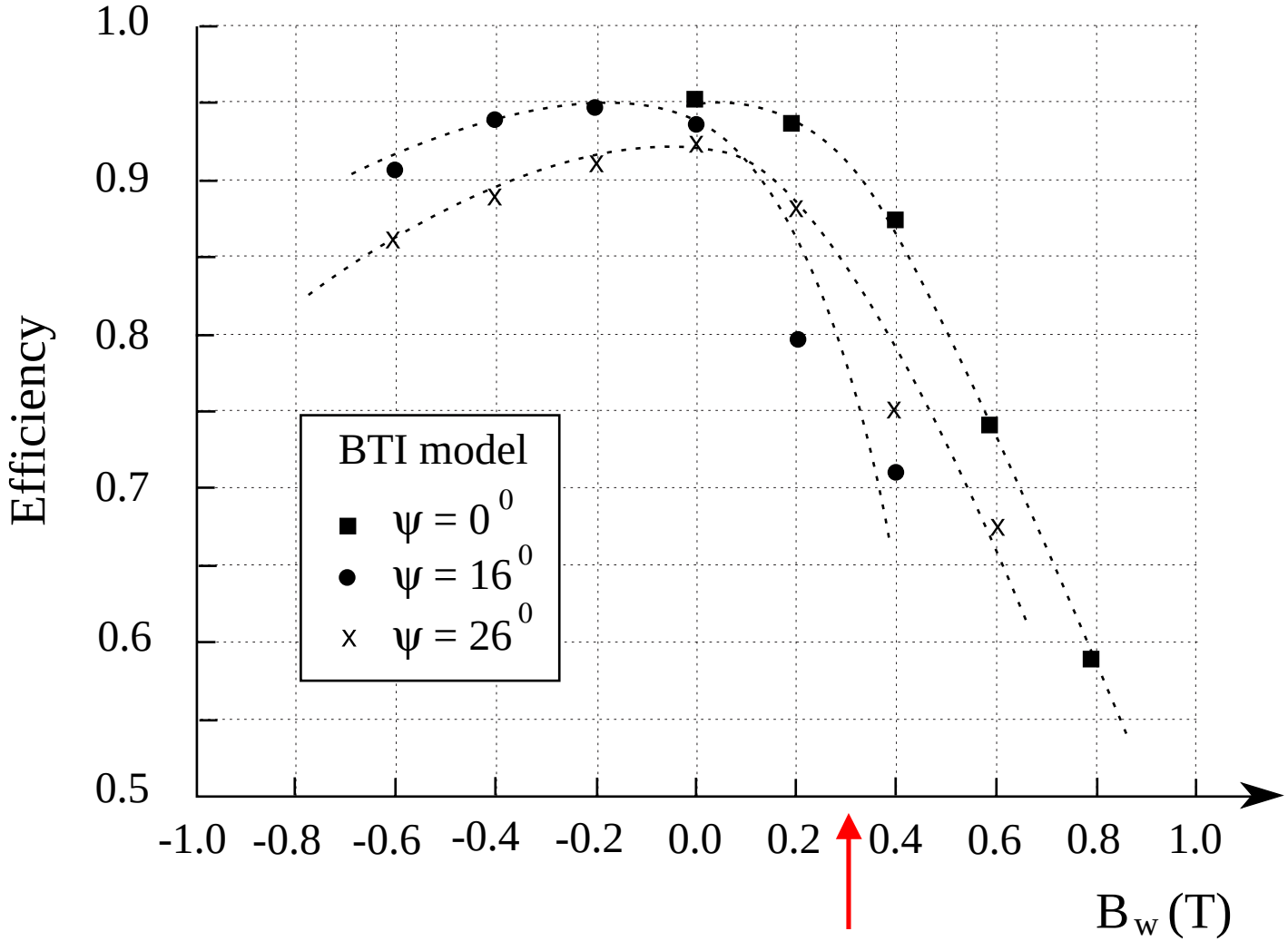
Trigger Efficiency Study in Overlap Region

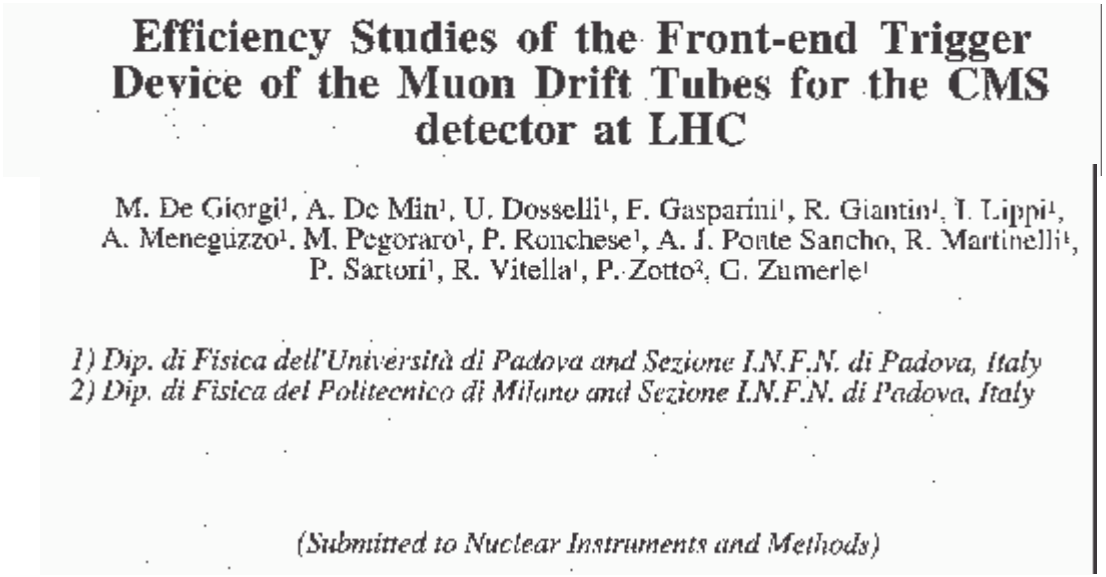
- Question: What is the increase in acceptance when overlapping ME1/3?

- Facts:
  - Overlap region covers $0.9 < |\eta| < 1.2$
  - ME1/3 presently has only 75% coverage in φ
  - Trigger resolution using only ME1/3 and ME2/2 is not sufficient to reduce single muon trigger rate in overlap region
  - MB1 and MB2 have only 87% coverage in φ
  - MB1 and MB2 will suffer inefficiency from fringe B-fields in overlap region

- Study:
  - Find efficiency for 2 or more stations to fire in overlap region
  - Require one hit in MB1 or MB2 for sagitta measurement
    - Rate reduction is questionable without MB1 at full luminosity, though, because P_T resolution is 40%

BTI Efficiency in Fringe Field





Efficiency Studies of the Front-end Trigger Device of the Muon Drift Tubes for the CMS detector at LHC

M. De Giorgi[1], A. De Min[1], U. Dosselli[1], F. Gasparini[1], R. Giantin[1], I. Lippi[1], A. Meneguzzo[1], M. Pegoraro[1], P. Ronchese[1], A. J. Ponte Sancho, R. Martinelli[1], P. Sartori[1], R. Vitella[1], P. Zotto[2], G. Zumerle[1]

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(Submitted to Nuclear Instruments and Methods)

"Looking at the obtained results we see that the effect is negligible for a field with components $B_n < 0.5T$ and B_w or $B_v < 0.2$ T. The CMS region where the magnetic field exceeds these values is only the far corner of the first muon station. Since this region is fully covered by the forward chambers we do not expect any trigger loss."

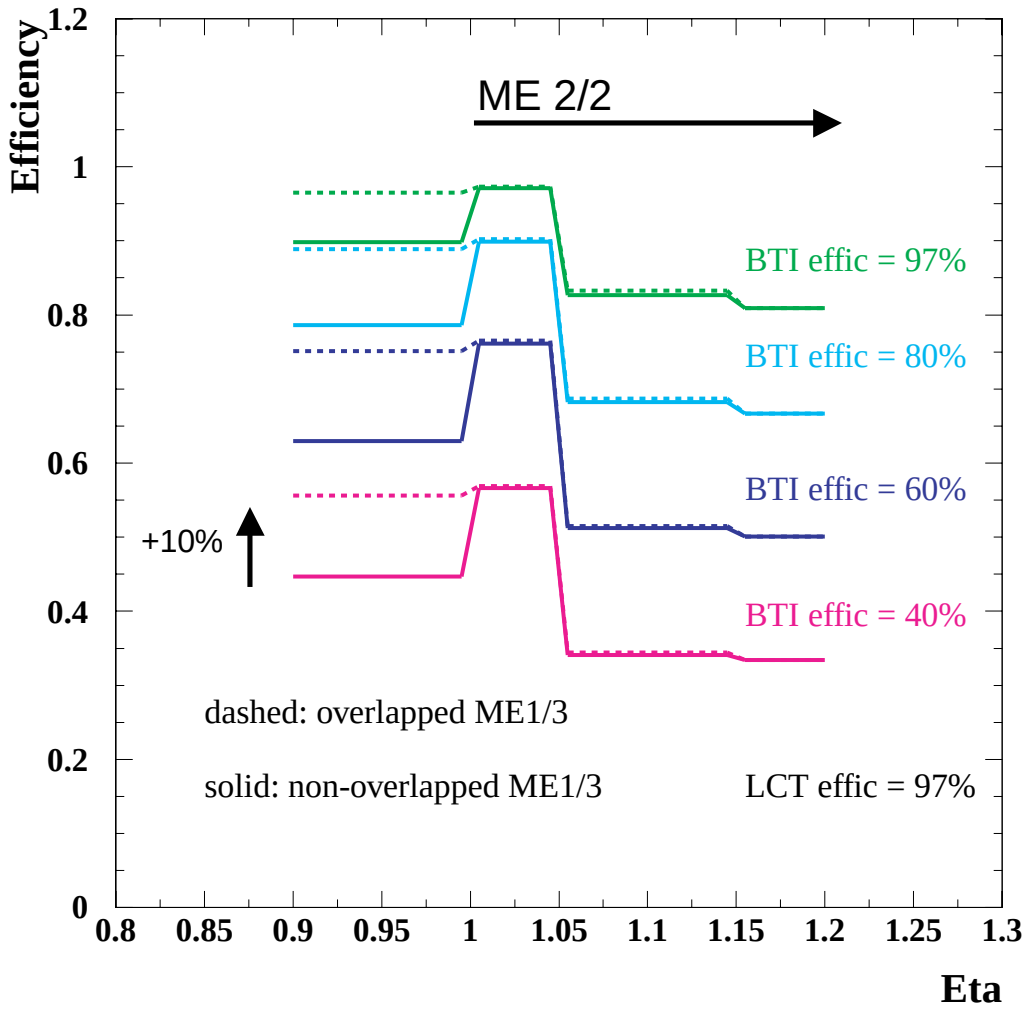
Inputs to Study

- Acceptance in φ for MB1 or MB2 is 87%
- Acceptance in φ for ME1/3 is 75% (or 100%)
- Acceptance in φ for ME2/2 is 100%

- Trigger efficiency for MB1 or MB2 is varied: 97%, 80%, 60%, 40%
- Trigger efficiency for ME1/3 or ME2/2 is varied: 97%, 80%, 60%

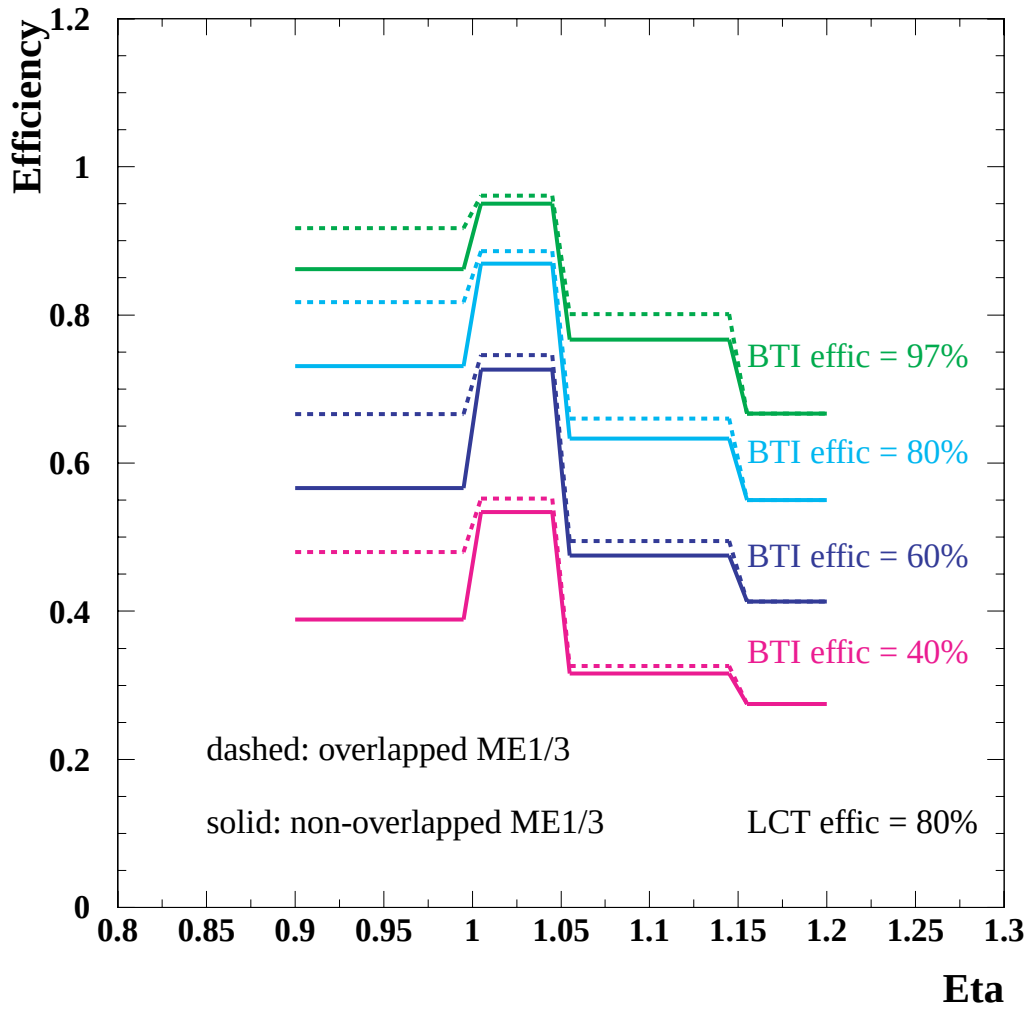
- Coverage in η is studied in 4 regions:
  - 0.9 < η < 1.0 – MB1, MB2, ME1/3
  - 1.0 < η < 1.05 – MB1, MB2, ME1/3, ME2/2
  - 1.05 < η < 1.15 – MB1, ME1/3, ME2/2
  - 1.15 < η < 1.2 – MB1, ME2/2

Efficiency of Overlap Region, Case 1

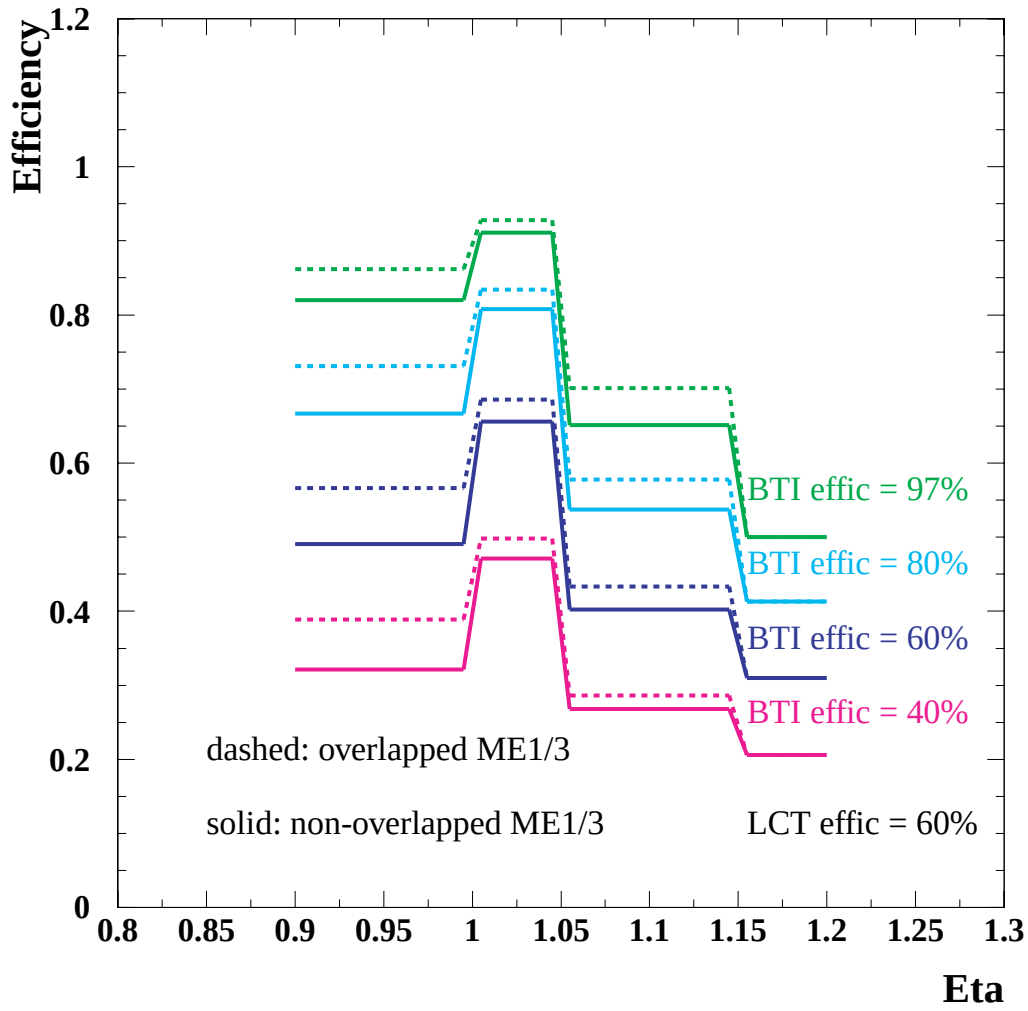


4% increase in acceptance overall

Efficiency of Overlap Region, Case 2



Efficiency of Overlap Region, Case 3



Summary of Overlap Efficiency

- Largest effect of overlapping ME1/3 occurs for $0.9 < \eta < 1.0$
  - 12% increase in acceptance (6% if MB1 hit is required)
  - Caused by lack of ME2/2 coverage
- Minimal effect elsewhere
  - A hit in either ME1/3 or ME2/2 has high efficiency
- Overall effect of overlapping ME1/3:
  - Increase in acceptance for overlap region is 4% (2% if MB1 hit is required)
  - Approximately independent of BTI and LCT efficiencies

Miscellaneous Issues

- 3-station sagitta measurement
- Effect of adding ME4
- Sector Partitioning in ME1
- CSC Geometry Problems

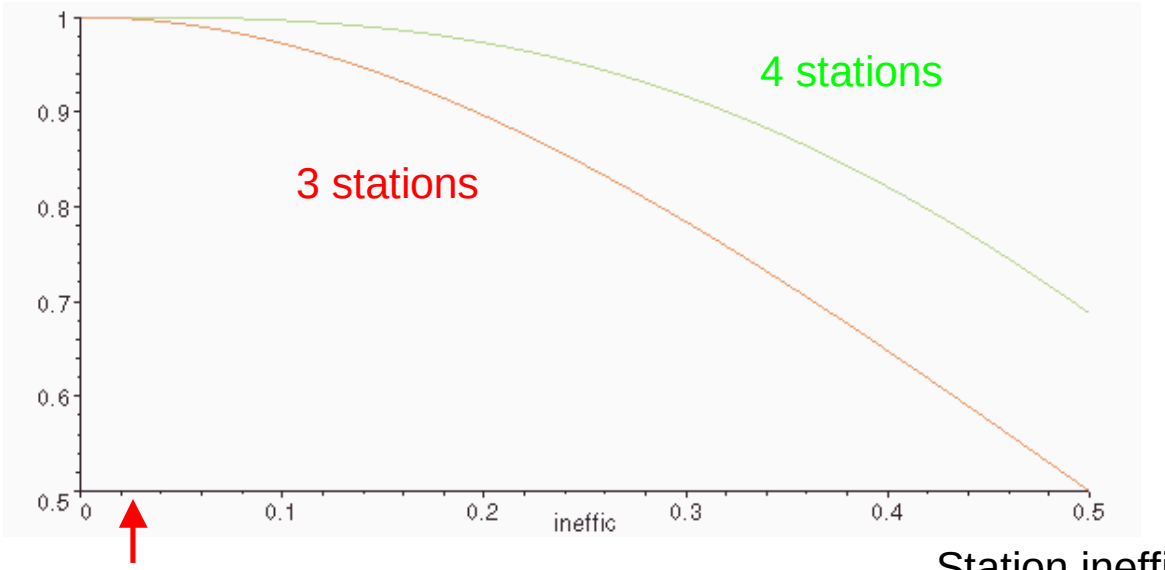
Sagitta Measurement in CSC Trigger

- Estimated trigger resolution of CSC Track-Finder using only $\Delta\varphi$ measured between ME1 and ME2, 3, or 4 is about 30% for P_T
- This is barely sufficient to reduce single muon rate below 1 kHz per unit rapidity for any trigger threshold at full luminosity
- Must go beyond simple scheme of Vienna Track-Finder:
  - Require 3 station sagitta measurement to improve resolution to 20% or better
  - Would provide a safety factor of at least 100 in rate
- Little redundancy in CSC system which has only 3 stations, however

CSC Redundancy Studies

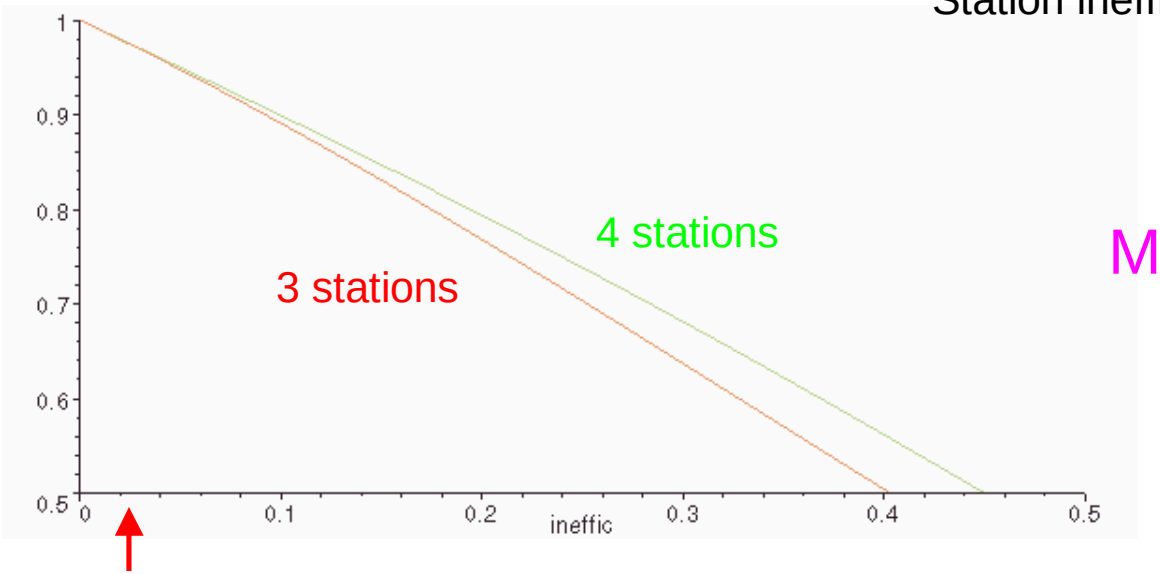
- Study efficiency for 2 or more stations to fire in CSC system as function of hit inefficiency (default scheme)
- Study efficiency for 3 or more stations to fire in CSC system as function of hit inefficiency (sagitta measurement scheme)
- Study for 3 and 4 stations
- Require a hit in ME1 for sufficient P_T resolution

2-Station Efficiency



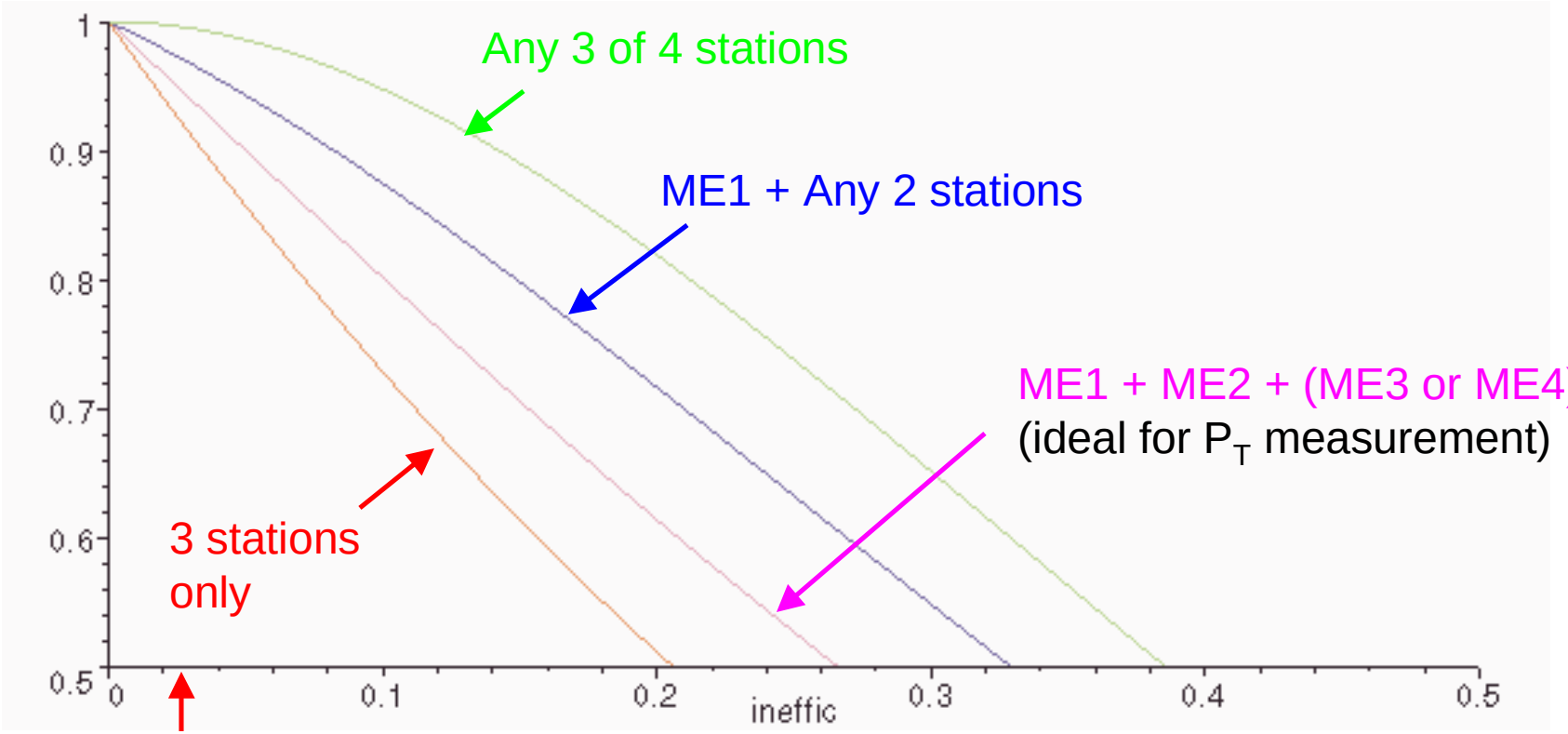
Any Two

Station inefficiency



ME1 + Any

3-Station Efficiency

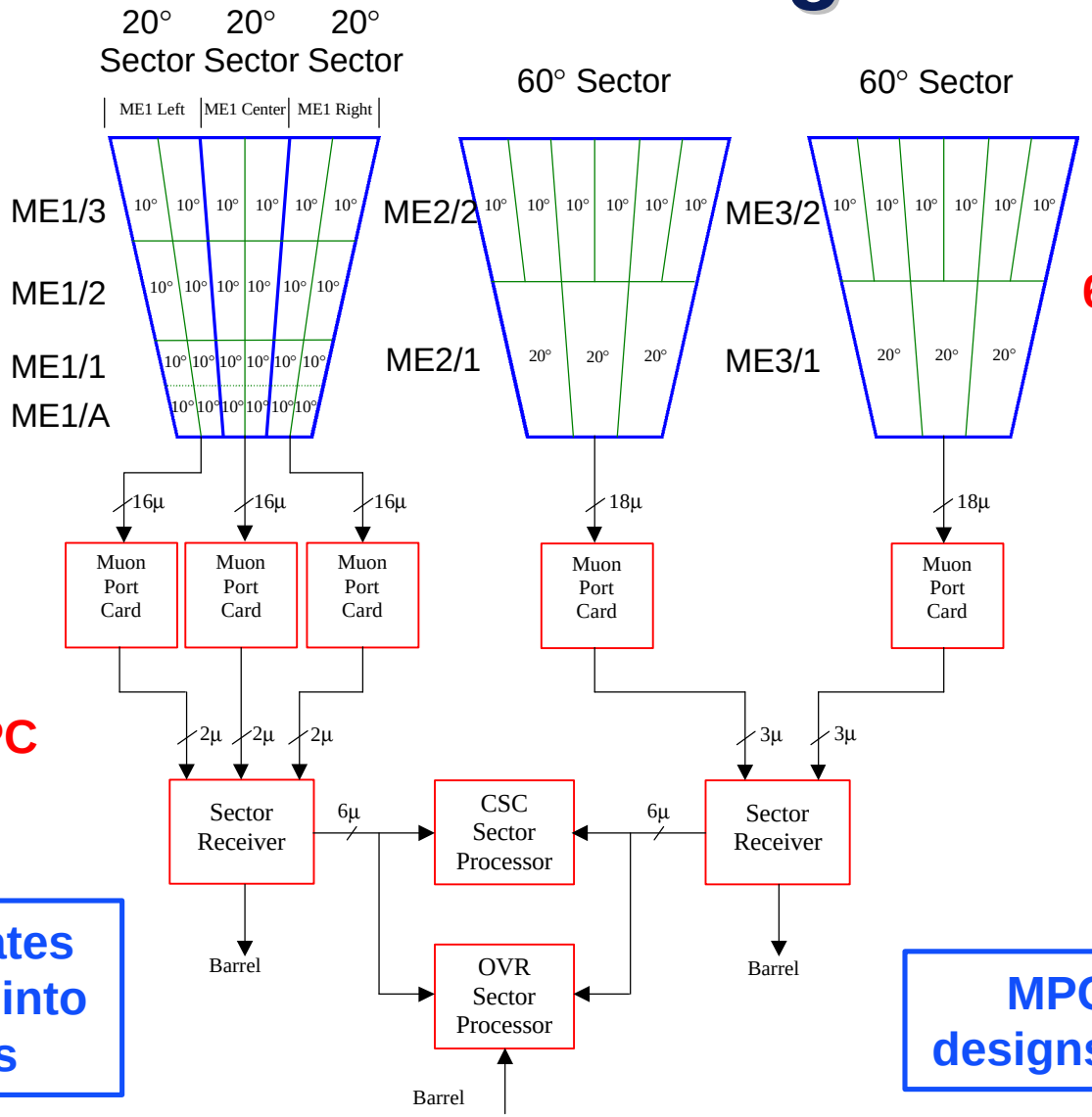


Comments

- Largest increase in acceptance occurs for $0.9 < |\eta| < 1.0$ when overlapping ME1/3 (0.2 units of rapidity)
- This should be weighed against a similar increase in the 3-station efficiency for $1.2 < |\eta| < 2.4$ if ME4 is recovered (2.4 units of rapidity)
- 3 stations may be necessary for a sagitta measurement to reduce the trigger rate
  - This will require some design work to determine feasibility
- Offline determination of LCT efficiency may benefit from 4 stations, if 3 stations are required to trigger (similar to a study of residuals)

Sector Partitioning for ME1 has Changed

30° → 20° sectors



2 → 3 MPC

3 → 2 µ / MPC

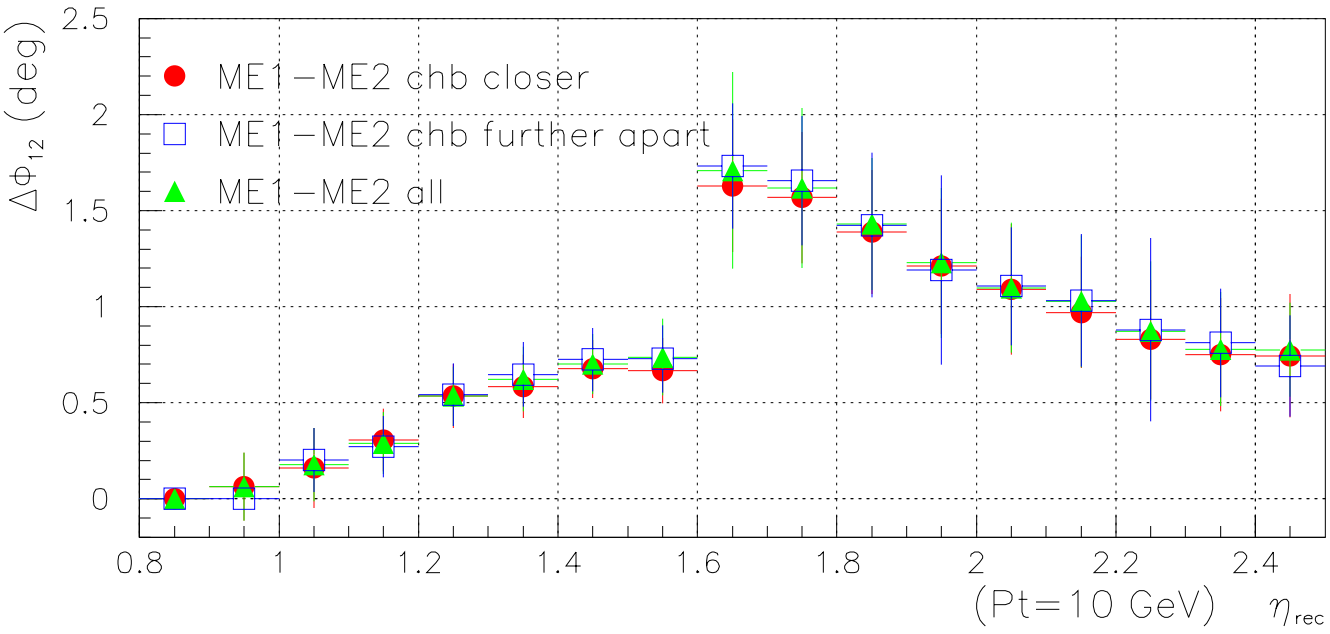
ME2 and ME3 60° sectors are unchanged

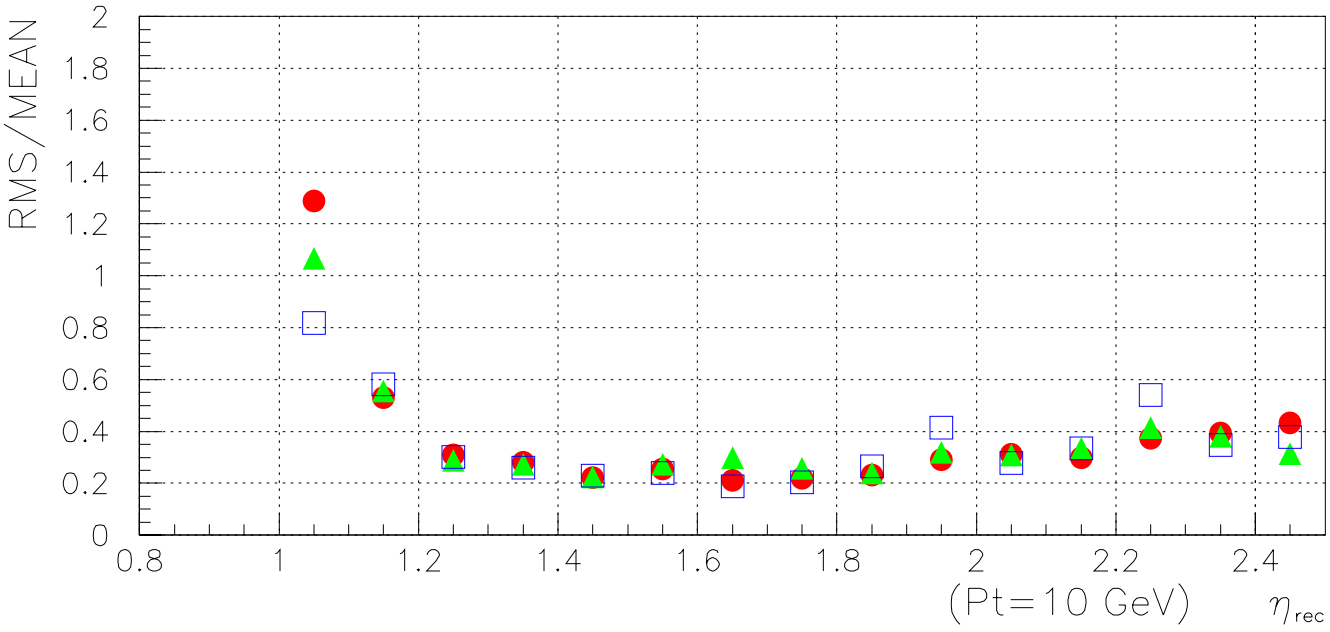
Accommodates split of ME1/1 into two regions

MPC and SR designs preserved

Issues concerning CSC staggering

- We have to live with it anyway
  - ME1 $\rightarrow$ ME2/1 (10° to 20° chambers)
  - Muons will cross φ boundaries
- Trigger rate depends on low P_T resolution
  - Multiple scattering dominates low P_T resolution
  - Low P_T muons bend $\Rightarrow$ cross φ boundaries
- Extrapolation of high P_T muons is not biased because bend angle $\approx$0 anyway
- Sector Receiver applies chamber alignment corrections
  - Consider staggering as an alignment correction!


ME1−ME2 chb closer
ME1−ME2 chb further apart
ME1−ME2 all
$\Delta\Phi_{12}$ (deg)
2.5
2
1.5
1
0.5
0
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
(Pt=10 GeV)
η_{rec}


RMS/MEAN
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
(Pt=10 GeV)
η_{rec}