



EMU Trigger Simulations

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Goal: Study reconstruction of Pt of muons in the End Cap chambers at the trigger level, to help in the design of the End Cap Track-Finder.

Simulation:

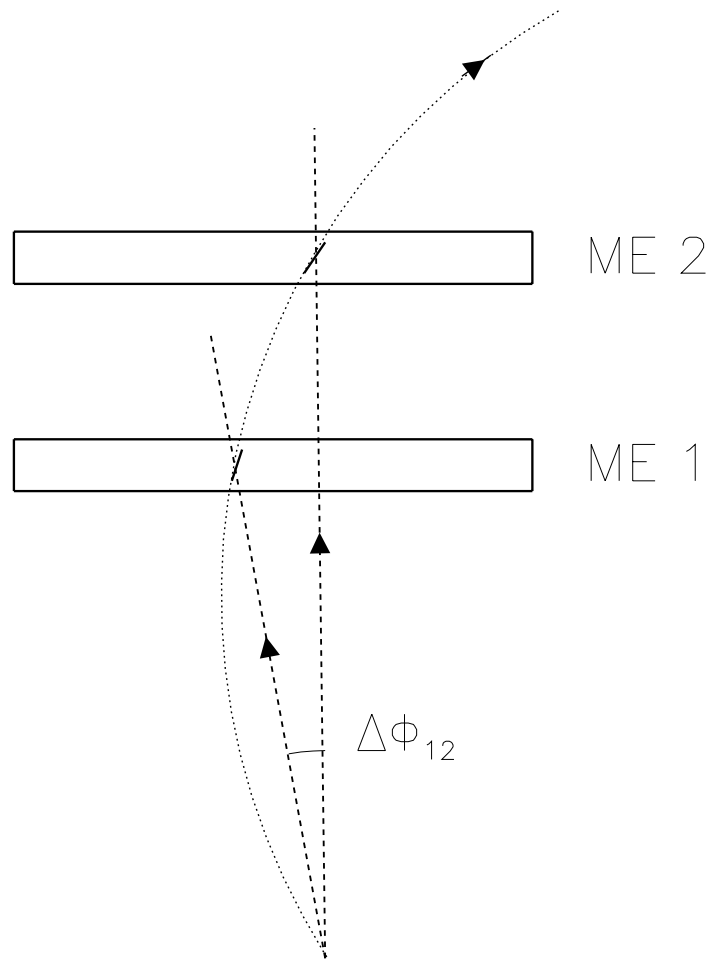
- use CMSIM 114
 - mf.tz has wrong strip staggering !
It was corrected for this study
 - For CMSIM 115,
 - * staggering was not fixed
 - * ME4 is not in the geometry file
 - * MB chambers have similar efficiency as in CMSIM 114
- Produced single muon events at various Pt, in $0.9 < \eta < 2.4$ range with no backgrounds
- Cathode strips and anode wires that carry hits caused by traversing muon are used to reconstruct the trigger primitives (high Pt patterns only) (refer to CMS TN/96-69)

- Study the dependence of $\Delta\phi$ on η and Pt

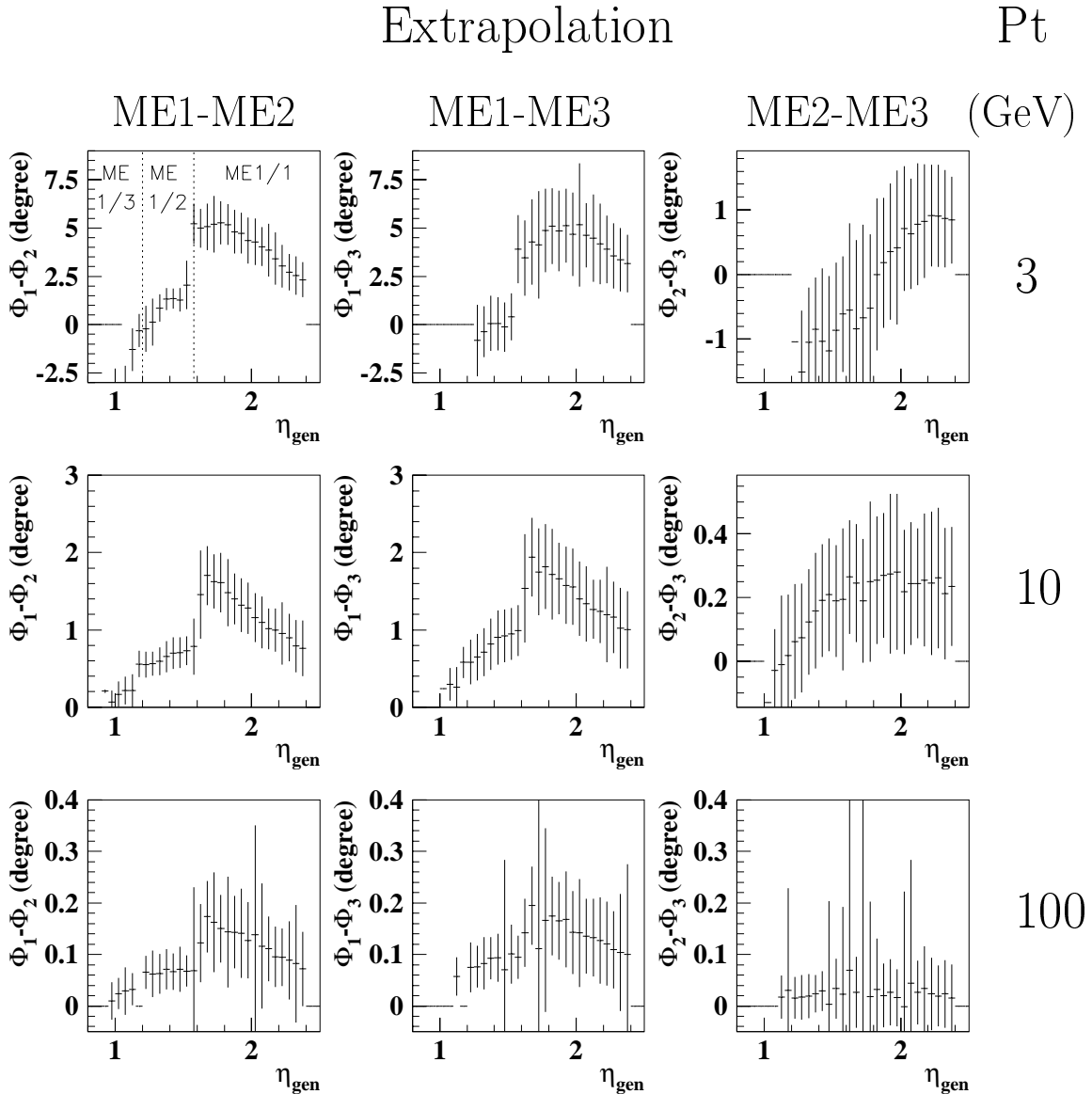
$$\Delta\phi : \Delta\phi_{12} = \phi_1 - \phi_2$$

$$\Delta\phi_{13} = \phi_1 - \phi_3$$

$$\Delta\phi_{23} = \phi_2 - \phi_3$$



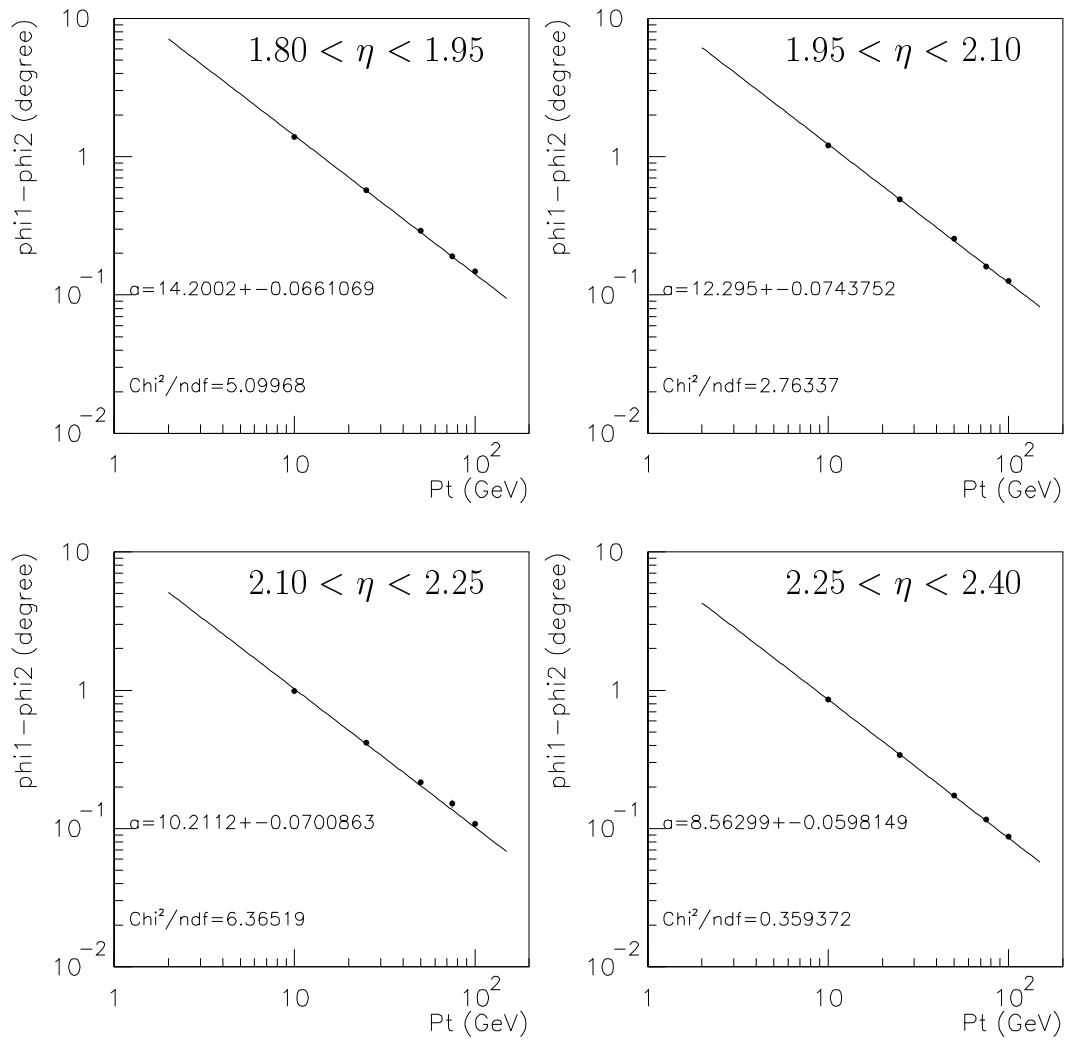
$\Delta\phi$ vs. η_{gen} at different Pt



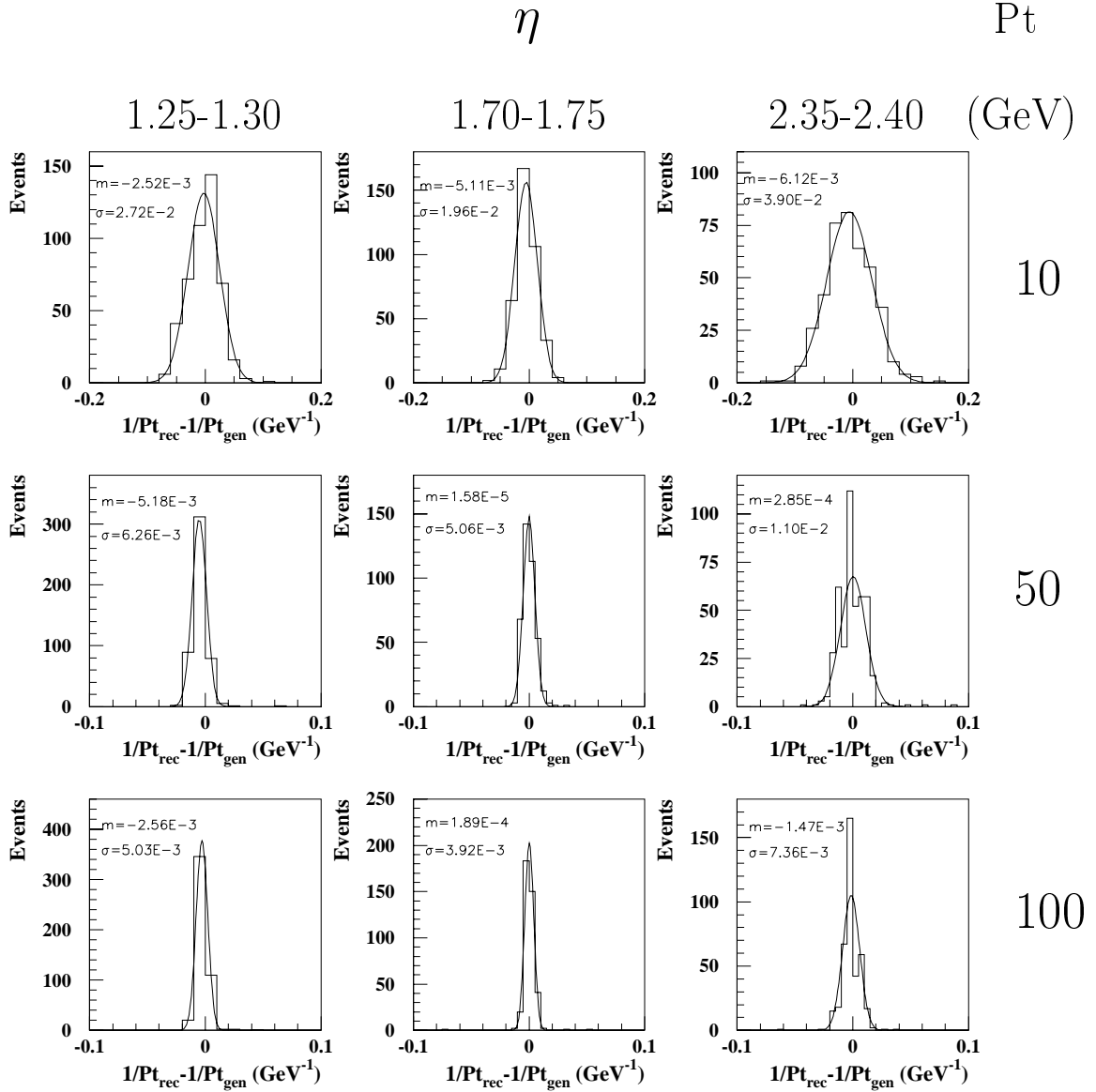
- “Error” bars are the RMS of the spread
- $\Delta\phi_{\text{Max}} \lesssim 9^\circ \quad 5^\circ + 2\sigma \quad , \quad \sigma \approx 2^\circ$.
 $\Delta\phi < 15^\circ \Rightarrow$ drop 2 MSB from 60° range in Track-Finder
- Jump in $\Delta\phi$ at $\eta_{\text{gen}} \sim 1.6$ for ME1-ME2 and ME1-ME3 is due to ME1/1 and ME1/A being closer to IP compare to ME1/2 and ME1/3

Parameterize $\Delta\phi$ vs. Pt and η

- Fit to $\Delta\phi = A(\eta)/Pt$
- Invert relation to obtain Pt

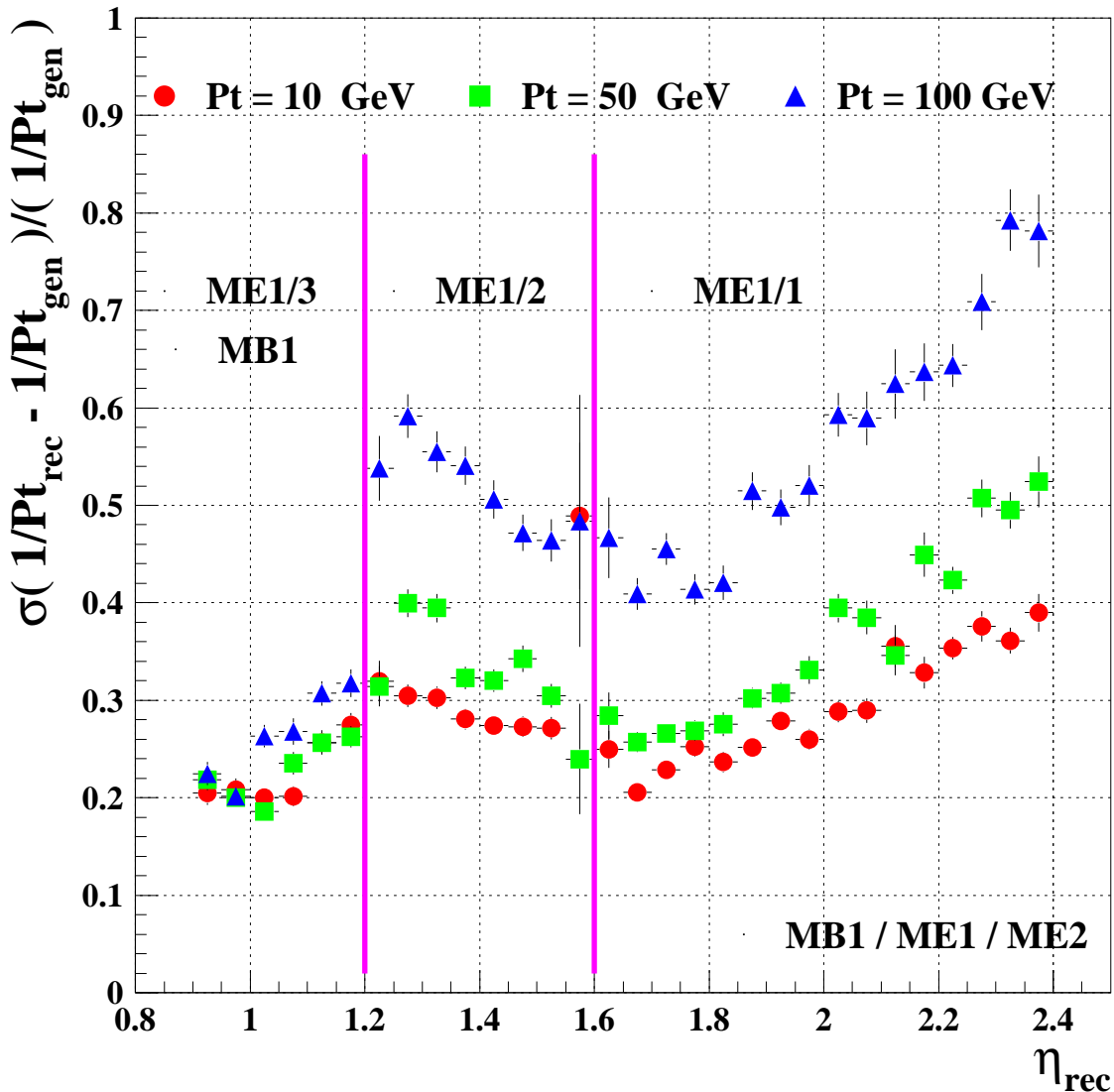


$\frac{1}{P_{t_{\text{rec}}}} - \frac{1}{P_{t_{\text{gen}}}}$ Distributions



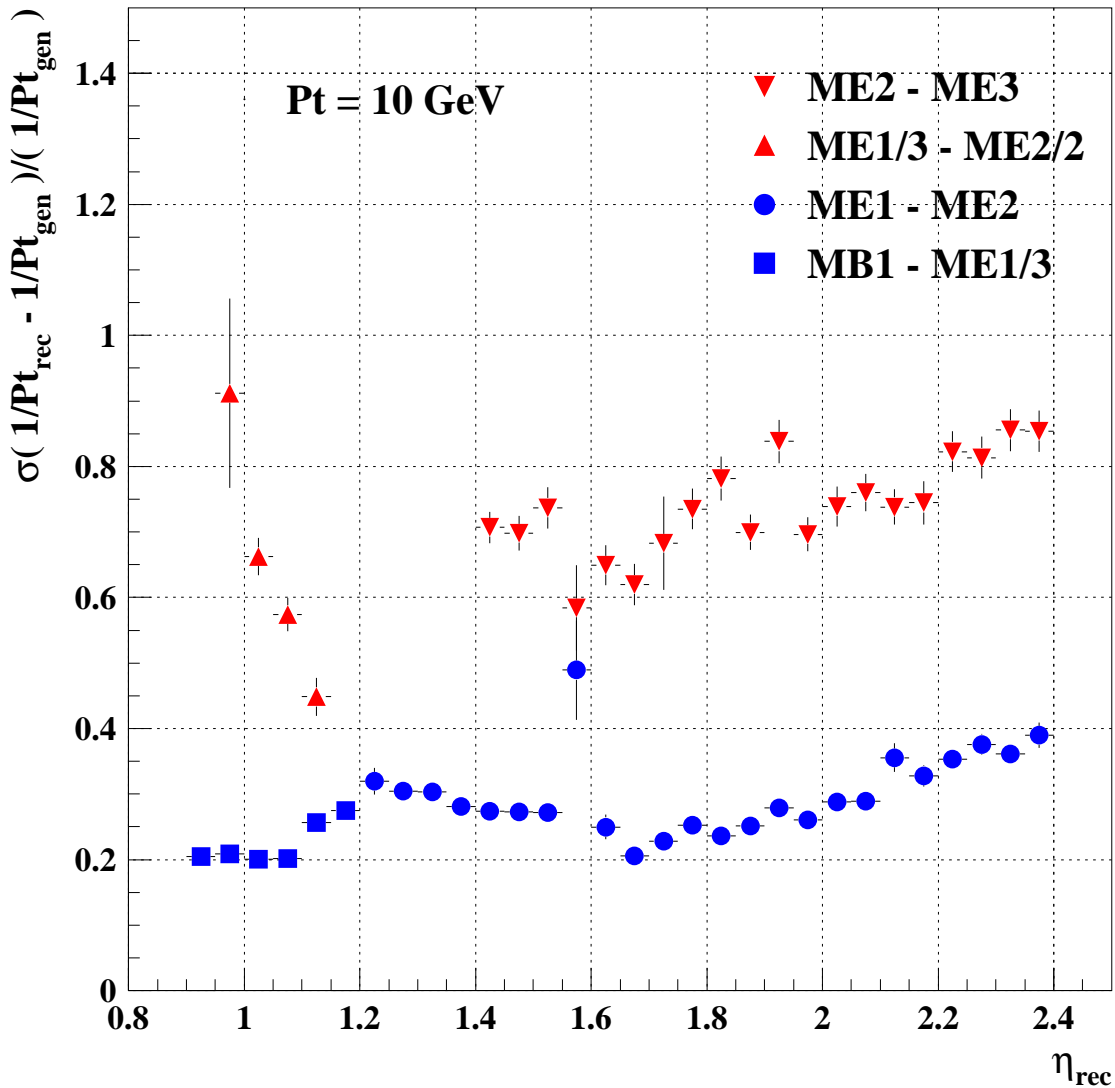
- $\frac{1}{P_{t_{\text{rec}}}} - \frac{1}{P_{t_{\text{gen}}}}$ for single muon events, with no background
- Distributions are Gaussian. No significant tails

Resolution of $1/Pt$ as function of η



- Pt_{rec} obtained from $\Delta\phi$ measured between MB1-ME1 ($0.9 < \eta < 1.2$), and ME1-ME2 ($1.2 < \eta < 2.4$).
- Resolution $\sim 30\%$ at low Pt
- Resolution in $2.2 < \eta < 2.4$ may be poorer since in CMSIM 114 there are 65 cathode strips in ME1/A instead of 48
- Expected to be improved as Track-Finder design evolves

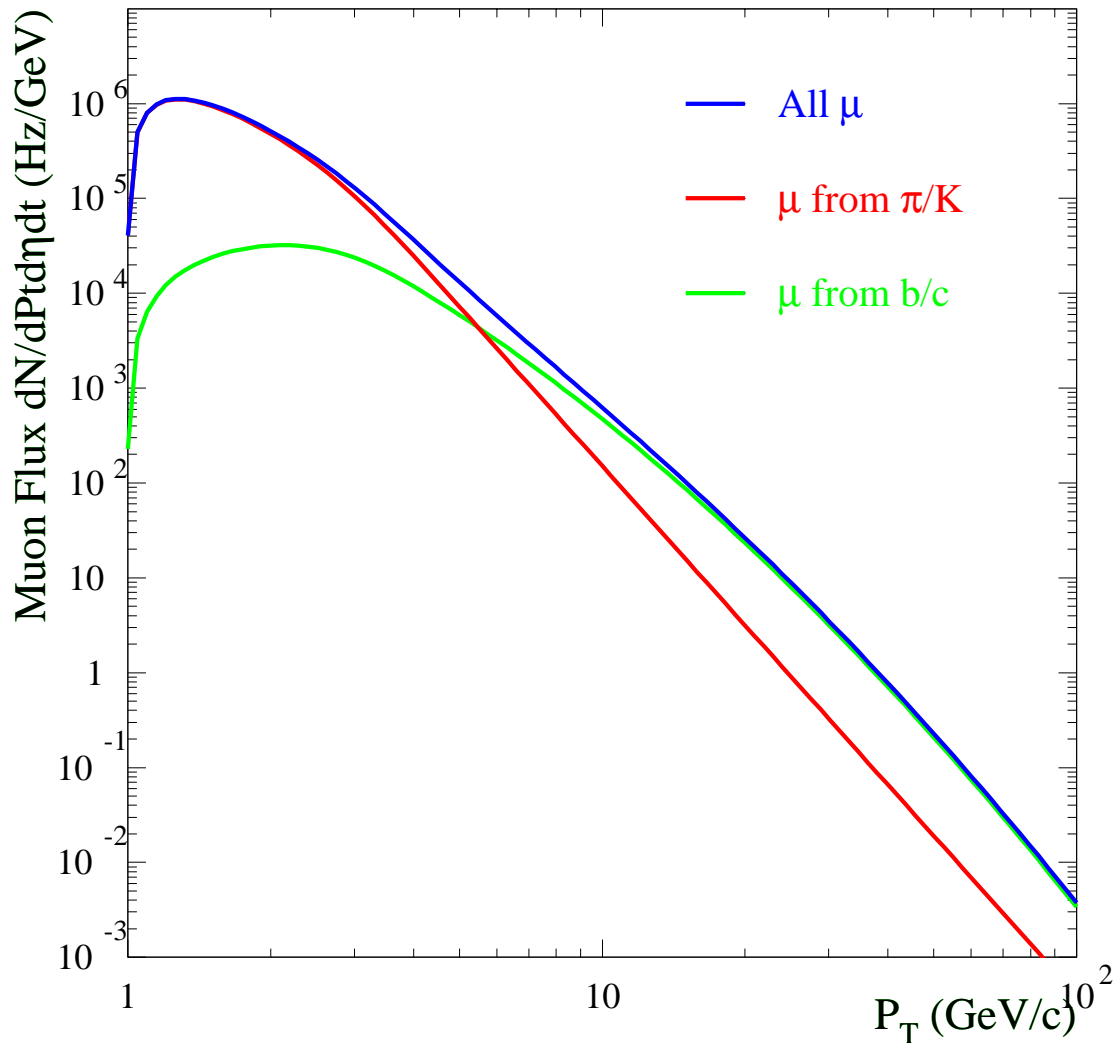
1/Pt Resolution with and without Measurements in MB1 or ME1



- $1/Pt$ resolution $\sim 70\%$ without MB1 in overlap region, or without ME1 in endcap
- Cannot satisfy single muon rate requirement without ME1 in the End Cap region, or without MB1 in the overlap region

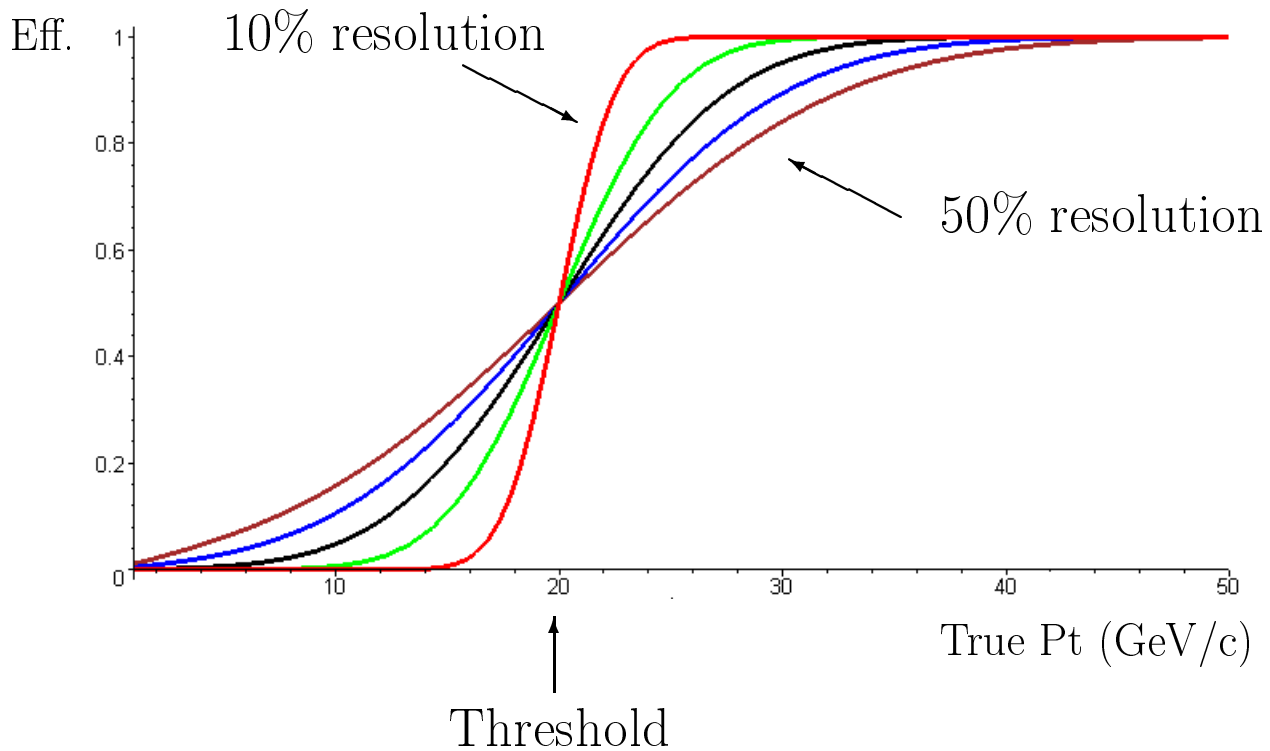
Study of Single Muon Rate in CSC

Estimated Muon Flux



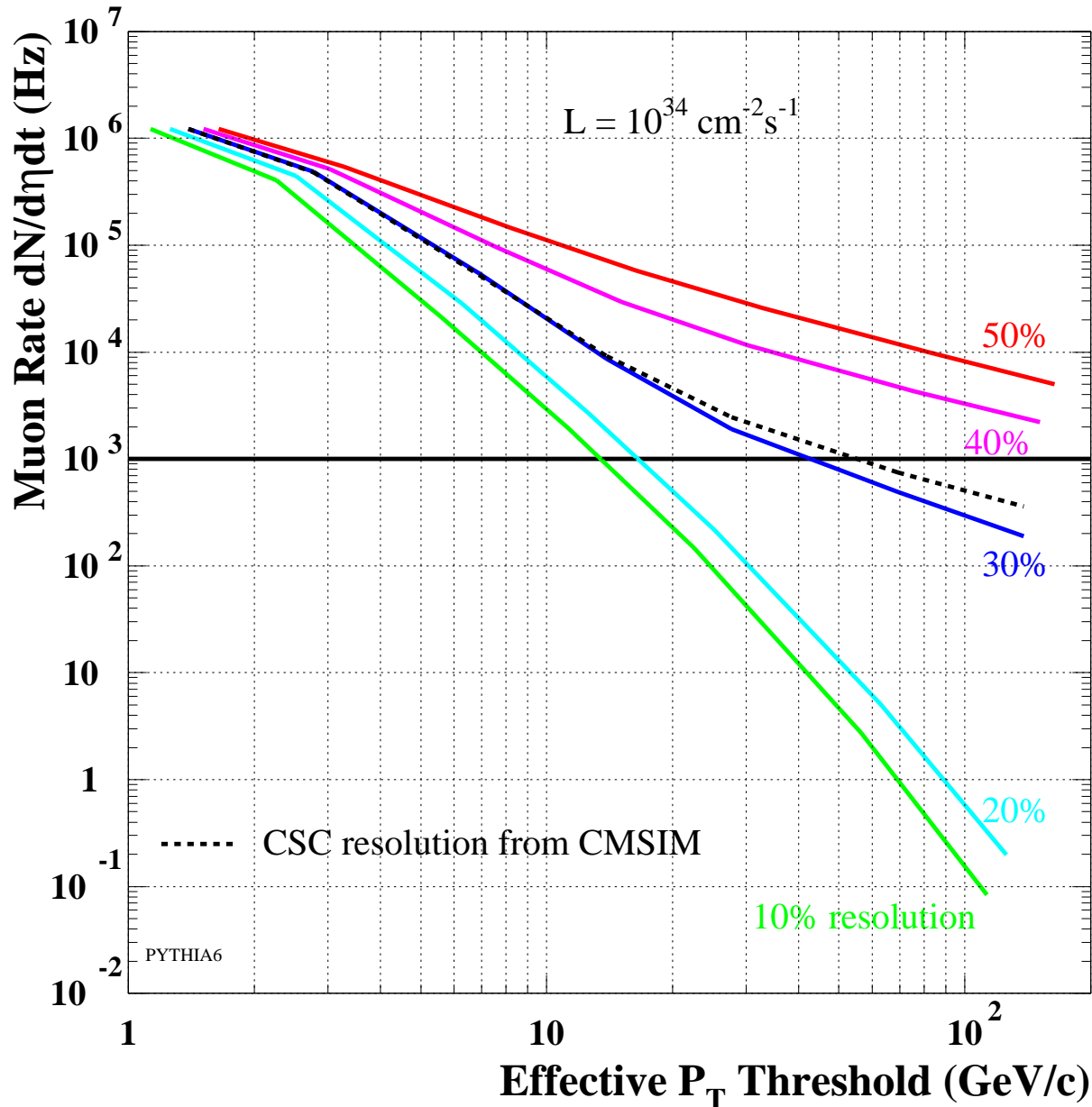
- Estimate muon flux at $L = 10^{34}$ from QCD events
 - Parameterization based on Pythia (CMS Note 1997/096)
 - Includes π/K which decay before calorimeter
- Fold in probability to punch through calorimeter in endcap region (determined from CMSIM)
- Assume 100% chamber efficiency

Trigger Efficiency Curves



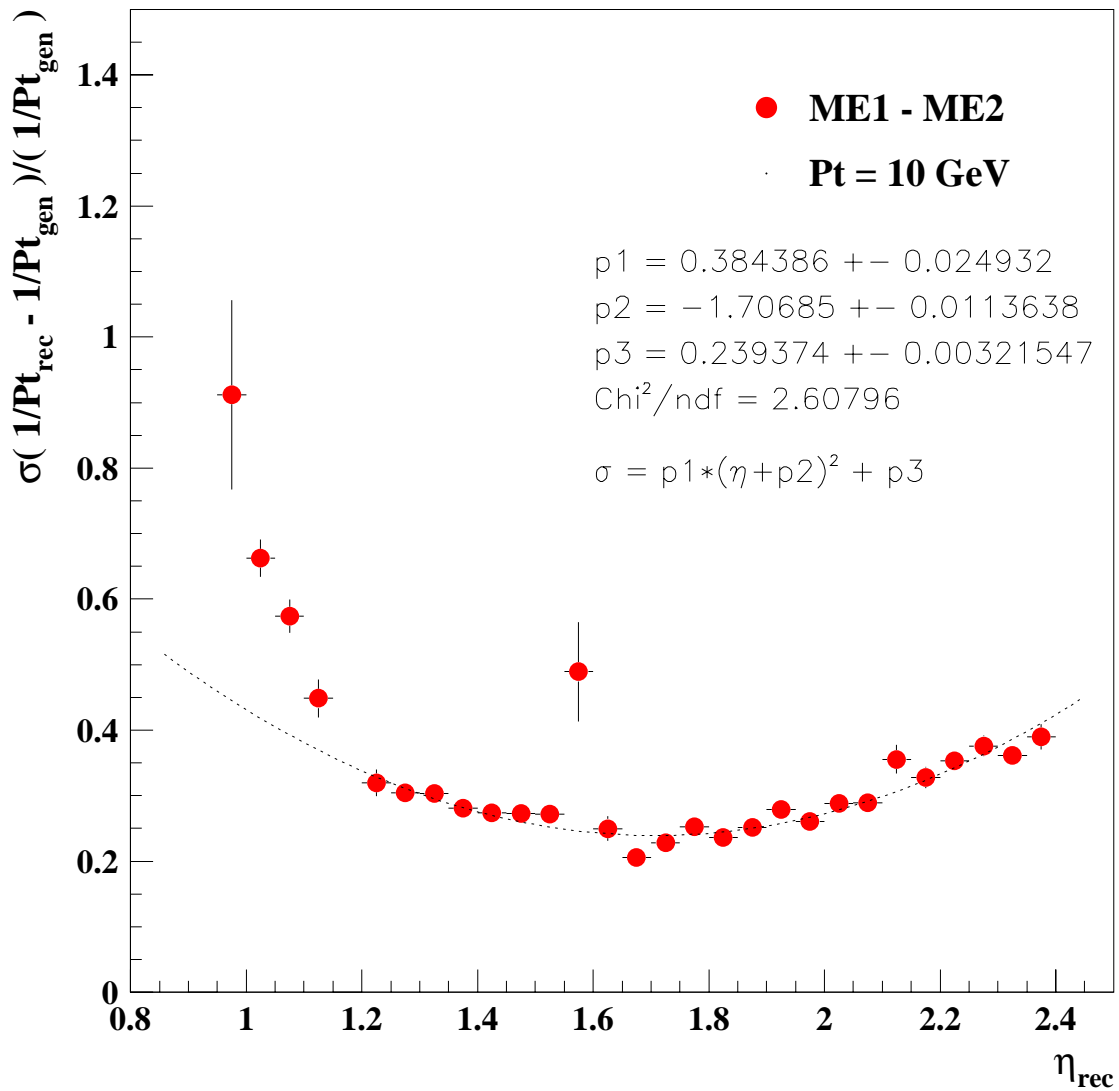
- Assume Gaussian errors for $1/Pt$ resolution
- Convolute muon flux with trigger efficiency curve to determine trigger rate

Single Muon Trigger Rates in CSC



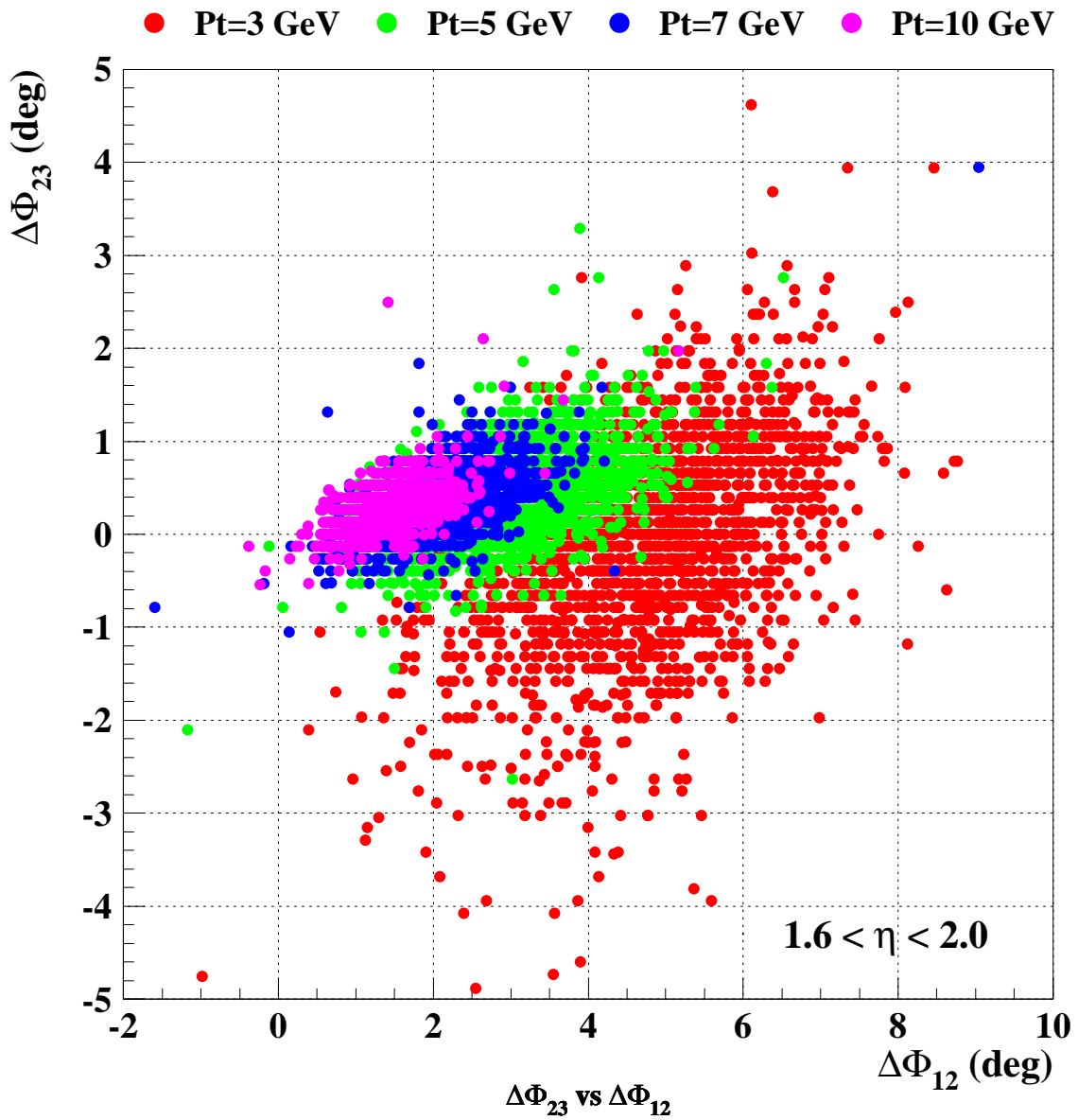
- Single μ rate from Pythia, convoluted with efficiency curve
- Threshold set for 90% efficiency
- Require rates < 1 kHz per unit rapidity
- Not satisfied for Pt resolution worse than 30%

Parameterize Resolution as Function of η



- For $Pt = 10$ GeV (end cap region only)

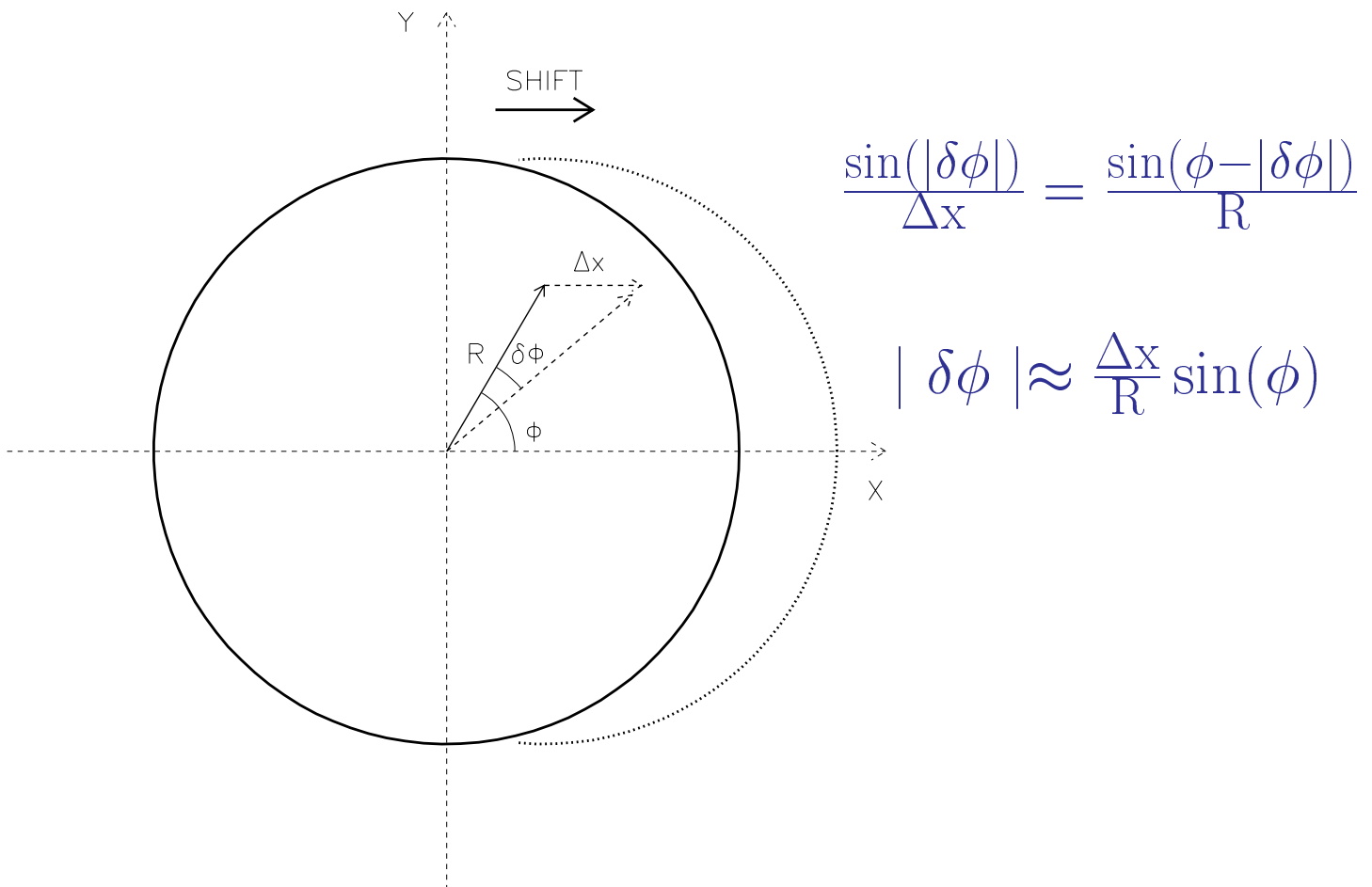
$\Delta\phi_{23}$ vs. $\Delta\phi_{12}$



- Using the relation between $\Delta\phi_{23}$ and $\Delta\phi_{12}$ to improve resolution at low Pt

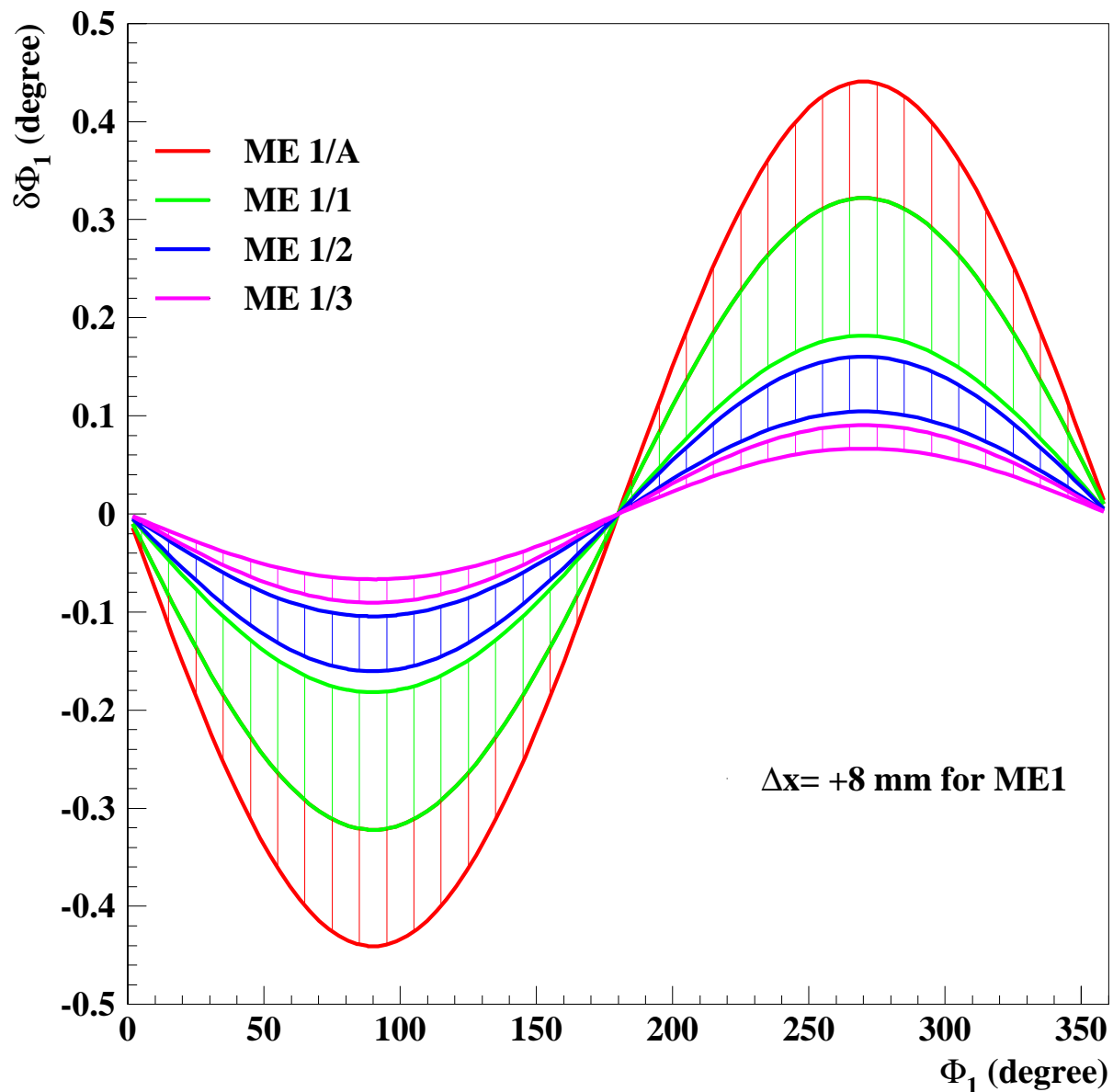
Effect of Misalignment of CSC on Track-Finder

- Estimate overall accuracy of station placement ≈ 3 mm (from Dick Loveless)
- \Rightarrow relative misalignment between 2 stations $\lesssim 6$ mm
- Simulate effect by misaligning ME1 by $\Delta x = +3, +8$ mm



- Different values of $\delta\phi_1$ at different locations in ME1
- $\phi_1 \rightarrow \phi'_1 = \phi_1 + \delta\phi_1$

$\delta\phi_1$ vs. ϕ_1 for $\Delta x = +8$ mm in ME1

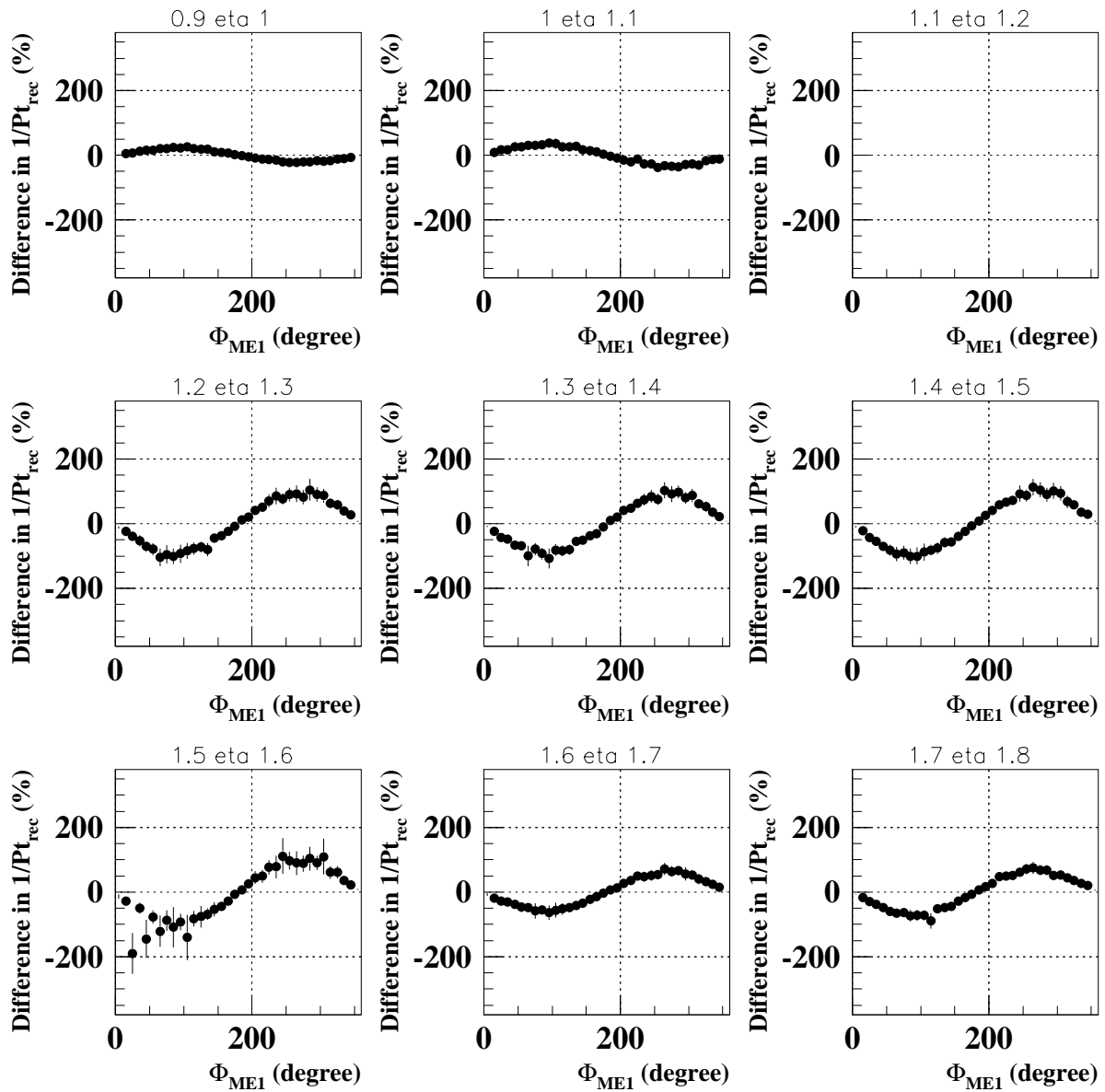


- $|\delta\phi_1|$ is larger for the trigger primitives located in the chambers closer to the beam pipe
- $\delta\phi_1$ has opposite signs for trigger primitives in opposite halves of the station

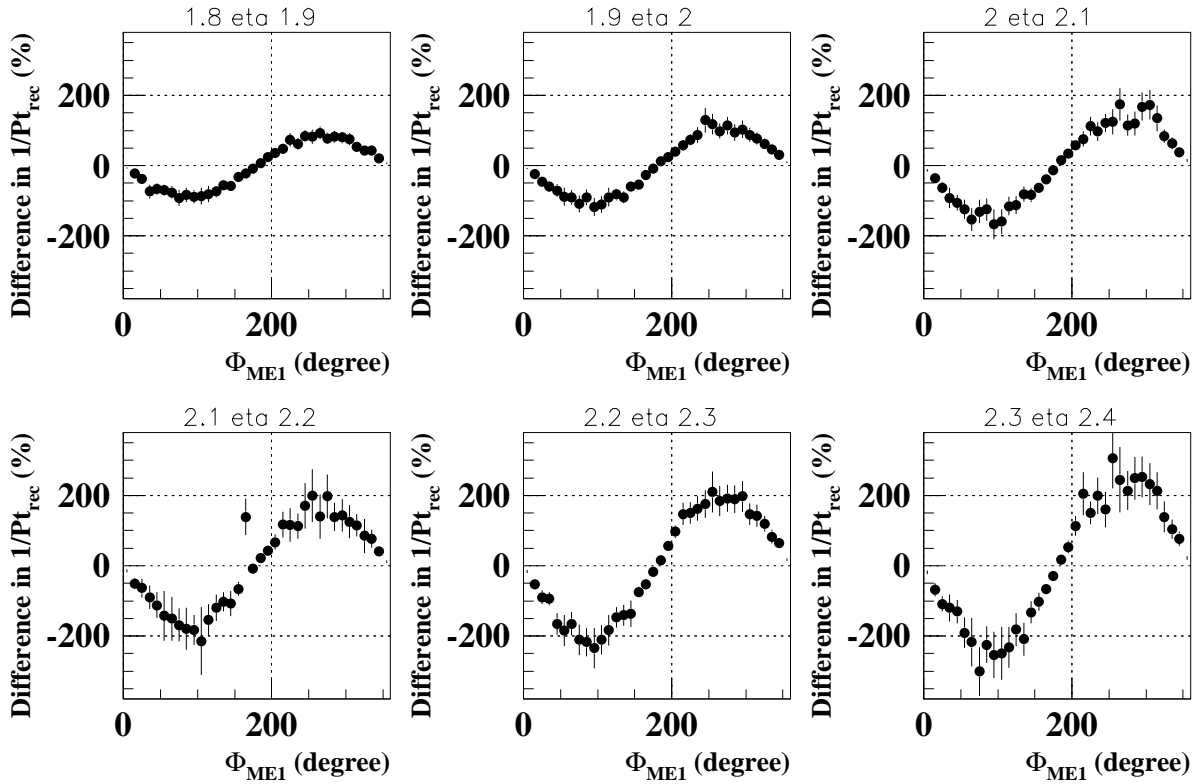
Effect on the Reconstruction of $1/Pt$

- $1/Pt$ obtained from $\Delta\phi$ measured between MB1-ME1 ($0.9 < \eta < 1.2$), and ME1-ME2 ($1.2 < \eta < 2.4$)
- Difference in $1/Pt = \frac{1/Pt_{\text{misaligned}} - 1/Pt_{\text{aligned}}}{1/Pt_{\text{aligned}}}$

MB1-ME1-ME2 +8mm ME1 Pt=50 GeV



MB1-ME1-ME2 +8mm ME1 Pt=50 GeV



For +3 mm :

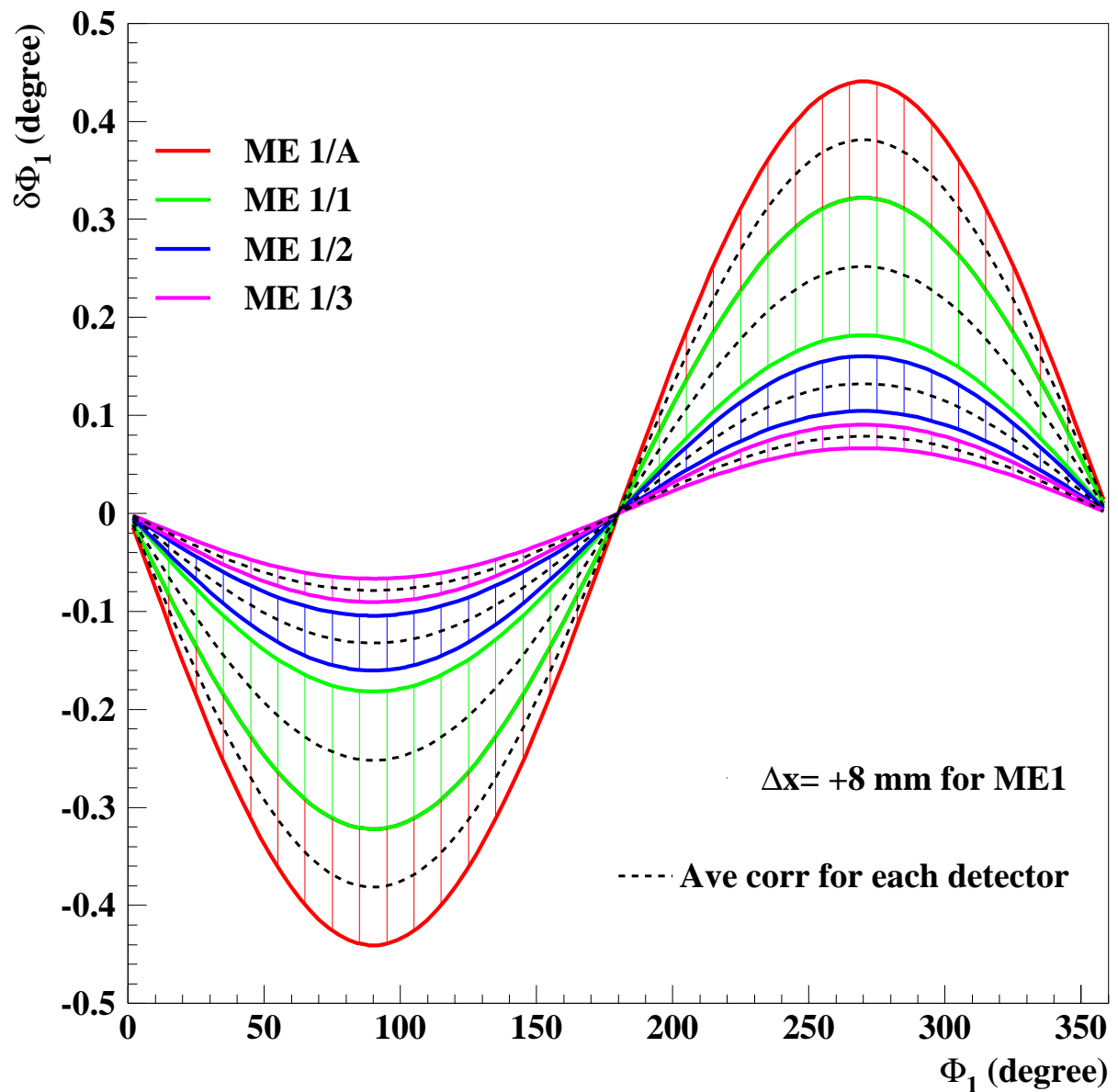
- $| \text{Difference in } 1/Pt | \lesssim 20\%$ (for Pt = 10 GeV)
 $\lesssim 100\%$ (for Pt = 50 GeV)

For +8 mm :

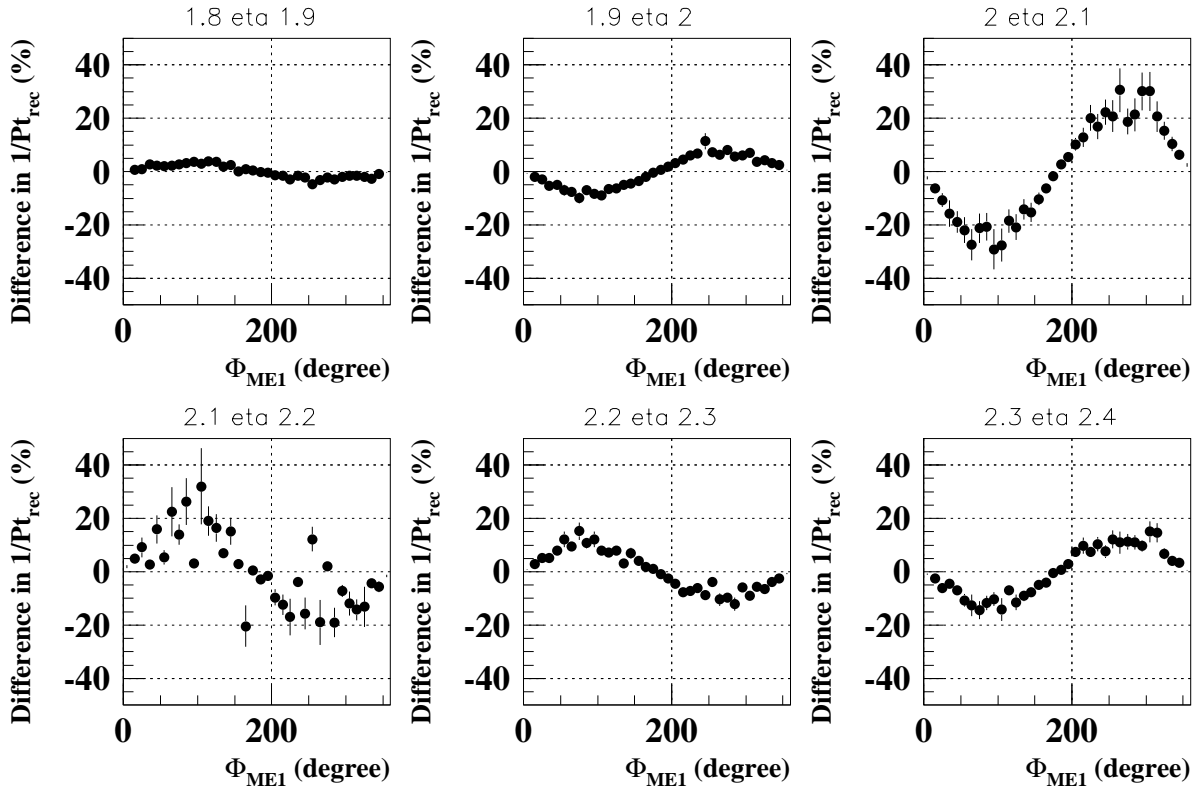
- $| \text{Difference in } 1/Pt | \lesssim 50\%$ (for Pt = 10 GeV)
 $\lesssim 200\%$ (for Pt = 50 GeV)

Correction on ϕ due to Misalignment

- Perform an average correction in each detector (e.g. ME1/A, ME1/1, ME1/2, ME1/3)
- Perform corrections in 15 bins of η ($0.9 < \eta < 2.4$)



MB1-ME1-ME2 +8mm ME1 Pt=50 GeV Ave Corr/det



- Average correction per detector
 - For +3 mm $| \text{Diff in } 1/Pt | \lesssim 2\%$ (for Pt = 10 GeV
resolution $\sim 30\%$)
 $\lesssim 10\%$ (for Pt = 50 GeV
resolution $\sim 30-40\%$)
 - For +8 mm $| \text{Diff in } 1/Pt | \lesssim 5\%$ (for Pt = 10 GeV)
 $\lesssim 20\%$ (for Pt = 50 GeV)
- Corrections in 15 bins of η (for +8 mm)
 - $| \text{Diff in } 1/Pt | \lesssim 10\%$ (for Pt = 50 GeV)

Summary

Preliminary studies show that :

- $1/P_t$ resolution $\sim 30\%$ for low P_t
- Single muon trigger rate will be too high if resolution worse than 30% , or without station ME1, and MB1 (for overlap)
- Corrections of ϕ of the LCTs in small number of η bins is sufficient to reduce the effect on the reconstruction of $1/P_t$ due to misalignment (for MB1-ME1-ME2)

Further studies

- Improve on the $1/P_t$ resolution for low P_t muons using the relation between $\Delta\phi_{12}$ and $\Delta\phi_{23}$
- Further studies on the station misalignments for ME2-ME3 (... expect greater effect due to smaller $\Delta\phi_{23}$), and its effect on trigger rates and efficiencies
- Write Track-Finder simulation program to test the Track Finding algorithm, its efficiency and rejection power on background
- Use more realistic LCT simulation (from UCLA) in CSC and DT (e.g. CMSIM 116)