Efficiency / Muon momentum scale

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for W change asymmetry presentation

Muon Reconstruction Efficiency

- Muon reconstruction efficiency is estimated using Tag and Probe method

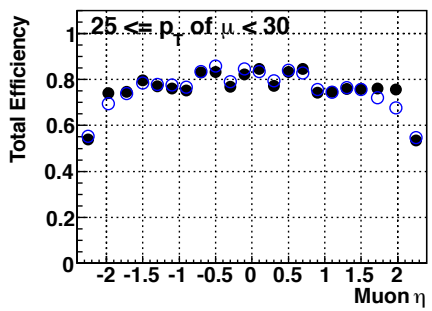
$$\varepsilon(\mu) = \text{Global} \times \text{ID} \times \text{Iso} \times \text{Trigger}$$

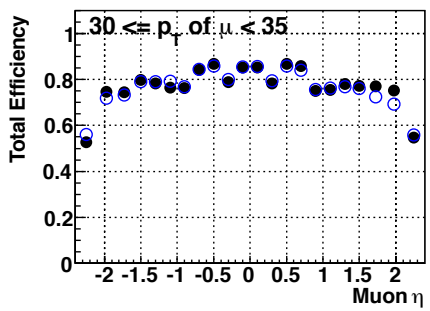
  - Drell-Yan sample is used to estimate the efficiency
    - Data : HLT_IsoMu24 triggered sample
    - MC : Powheg with Pythia parton showering
  - Tracking efficiency is confirmed to be ~ 100% and the scale factor of data to MC is 1.0 within the statistical uncertainty
    $\Rightarrow$ Exclude the tracking efficiency in $\varepsilon(\mu)$
  - The efficiency is estimated at a function of p_T (5 bins) and η (22 bins)
  - The background is estimated using the di-muon mass fitting

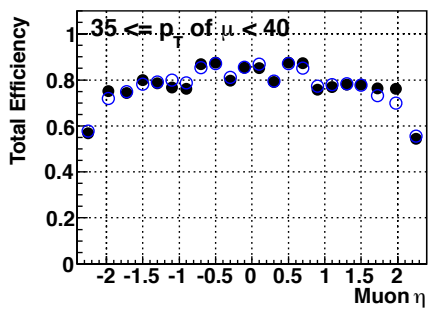
- The efficiency ratio of data to MC is applied into MC for better description of the signal shape
- The efficiency ratio of $\mu+$ to $\mu-$ is used to assign the systematic uncertainty

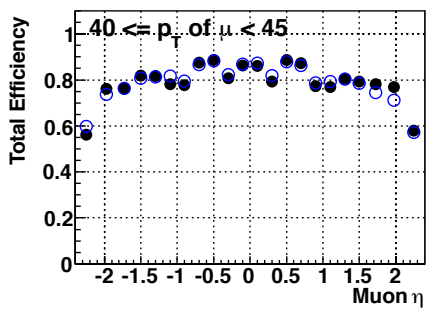
Efficiency in p_T and η

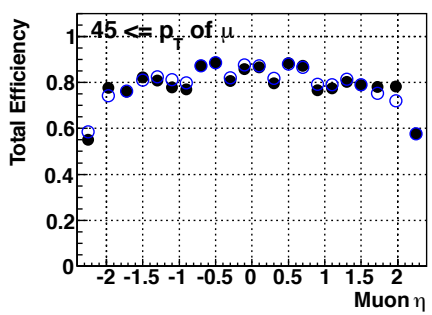
- Efficiency in p_T and η in data (black) vs. MC (blue) and its ratio

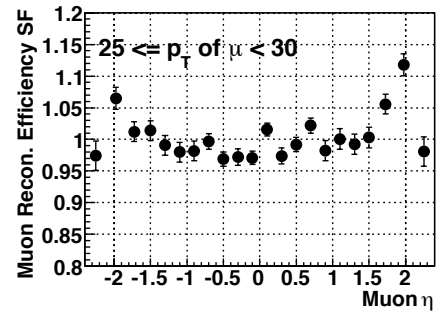


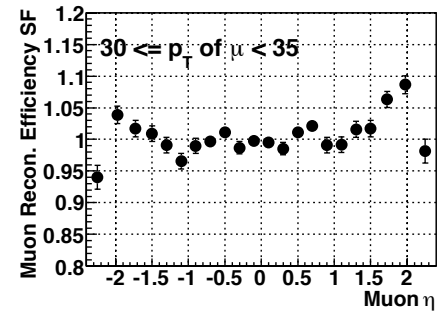


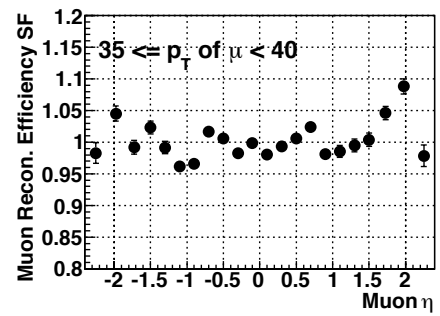


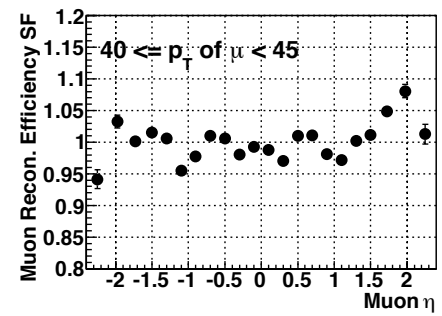


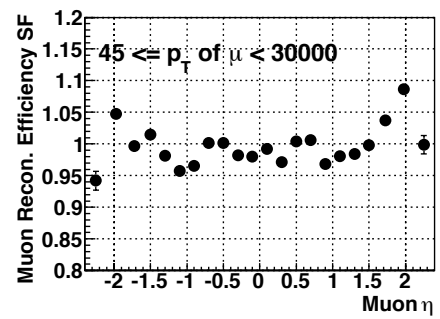








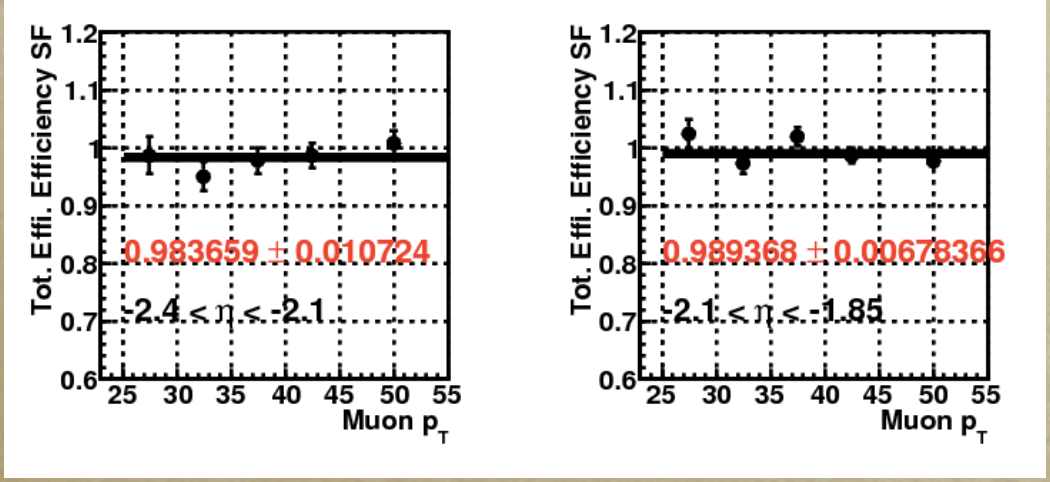




Efficiency Ratio of μ^+ to μ^-

- The efficiency ratio of μ^+ to μ^- in data is used to assign the systematic error

Forward region



The overall efficiency ratio in each η bin is estimated *by fitting in p_T ($f(x)=c$)*

The efficiency difference produces W charge asymmetry difference between $+\eta$ and $-\eta$ in the forward region

η bin	$\epsilon(\mu)$ Ratio of μ^+ to μ^-	η bin	$\epsilon(\mu)$ Ratio of μ^+ to μ^-
$-2.40 < \eta < -2.10$	0.9837 ± 0.0107	$2.10 < \eta < 2.40$	1.0144 ± 0.0110
$-2.10 < \eta < -1.85$	0.9894 ± 0.0068	$1.85 < \eta < 2.10$	0.9874 ± 0.0066
$-1.85 < \eta < -1.60$	0.9908 ± 0.0064	$1.60 < \eta < 1.85$	1.0081 ± 0.0063
$-1.60 < \eta < -1.40$	0.9910 ± 0.0058	$1.40 < \eta < 1.60$	0.9992 ± 0.0065
$-1.40 < \eta < -1.20$	1.0052 ± 0.0059	$1.20 < \eta < 1.40$	1.0070 ± 0.0061
$-1.20 < \eta < -1.00$	0.9969 ± 0.0061	$1.00 < \eta < 1.20$	0.9911 ± 0.0062
$-1.00 < \eta < -0.80$	1.0123 ± 0.0063	$0.80 < \eta < 1.00$	1.0084 ± 0.0063
$-0.80 < \eta < -0.60$	0.9940 ± 0.0042	$0.60 < \eta < 0.80$	1.0094 ± 0.0043
$-0.60 < \eta < -0.40$	0.9959 ± 0.0039	$0.40 < \eta < 0.60$	1.0006 ± 0.0040
$-0.40 < \eta < -0.20$	0.9996 ± 0.0052	$0.20 < \eta < 0.40$	1.0093 ± 0.0055
$-0.20 < \eta < 0.00$	1.0035 ± 0.0043	$0.00 < \eta < 0.20$	0.9880 ± 0.0041

Muon Momentum Correction

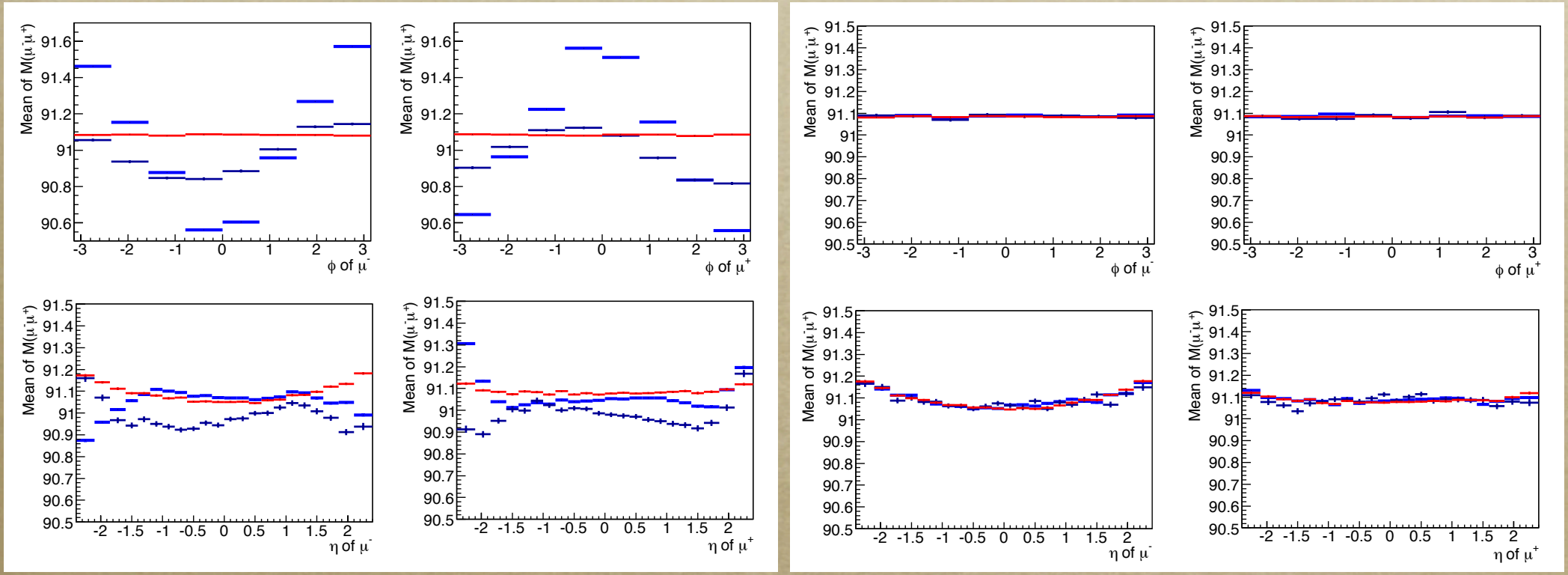
- Muon momentum correction is applied to remove Q, η, ϕ dependence
- Rochester correction (AN-2012/062, 298) is used to remove a bias
  - $<1/p_T>$ correction in (Q, η, ϕ) : remove muon momentum bias
    - $<1/p_T>$ correction is based on $<1/p_T>_{gen.}$ - $<1/p_T>_{rec.}$ in (Q, η, ϕ)
      - Reference is gen. level after FSR with detector resolution smearing
    - The additional correction using Z mass is propagated into $<1/p_T>$
      - Z mass is less sensitive to the efficiency or modeling effect
  - Global factors : match Z mass in MC to data
    - Z mass peak is set to be gen. Z mass (after FSR + resolution smearing)
      - Z peak is fitted using Breit-Wigner function ($88<M<94$ GeV/c^2)
    - Additional smearing is applied into MC to match with the data
- Rochester correction is extracted for W charge asymmetry
  - The correction is for 2011A data in CMSSW44x version
  - The eta binning is same with the binning of W charge asymmetry
    - $<1/p_T>$ correction binning in (η, ϕ) : 22x8 ($|\eta|$ up to 2.4)

Z Mass Profile in ϕ and η

- Z mass profile in ϕ and η before and after Rochester correction

Black : data
Blue : MC
Red : Generated MC

Before correction *After correction*



- Rochester correction removes all of the muon momentum bias
- The muon momentum resolution is reduced from 1.2 % to 0.12 % in data