Rochester Correction Update

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Q1) How do we obtain the $1/p_T$ distributions for recon. data and MC and those for gen. MC to derive $\langle 1/p_T \rangle$(reco) - $\langle 1/p_T \rangle$(gen) ?

=> MC doesn't describe exactly the data for the efficiencies
and also the kinematic distribution like Z Pt spectrum.
We estimated the muon efficiency scale factor of the data to MC as a function of eta
and this scale factor is applied into MC as the event weighting.
The trigger efficiency is also estimated in data and the measured trigger efficiency
as a function of eta is also applied into MC as the event weighting.
We also correct Z Pt spectrum in MC using the event weighting.

The event weighting factors for Z Pt spectrum and efficiencies are applied into MC for each event.
(recon. and gen. 1/pt distribution are obtained after applying the event weighting).
Therefore, if the event weighting factor is changed in eta or so,
the average of the reconstructed or the generated 1/pt in MC is also slightly changed
because the acceptance times the efficiency changes in eta and phi.

The 1/pt distribution in data is obtained without any event weighting.

<1/pt>(reco) in data : the average of the reconstructed 1/pt after all selections
(trigger requirement, muon ID cuts, and mass cut) in (eta,phi,Q)

<1/pt>(reco) in MC : the average of the reconstructed 1/pt after all selections
(trigger requirement, muon ID cuts, and mass cut) in (eta,phi,Q).
REMARK) <1/pt>(reco) in MC is after the event weighting for Z Pt and efficiencies correction factor.

<1/pt>(gen) : the average of the generated 1/pt after all selections
and with event weighting factor like <1/pt>(reco) in MC.
REMARK) the gen. 1/pt is 1/pt after FSR and also gaussian resolution smearing factor (done by MuscleFit)
is applied into the gen. 1/pt.

We got <1/pt> in the range of 1/pt<0.04 because MC cannot describe very precisely for low pt region.

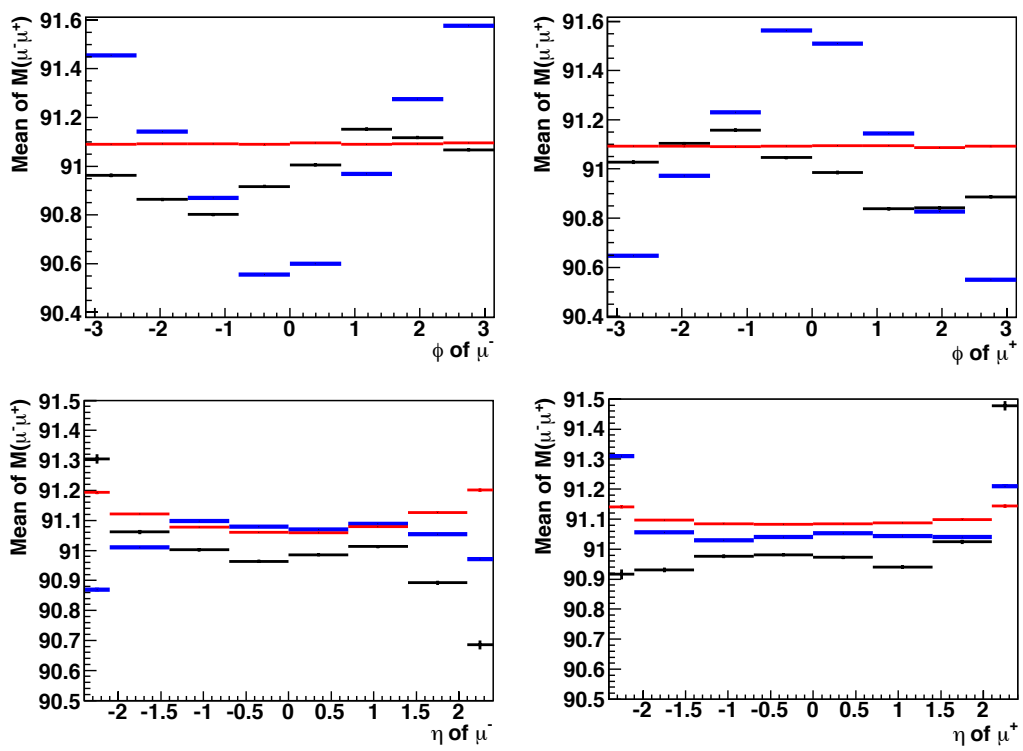
We iterated the procedure of getting <1/pt> correction several times until the correction is converged.
In each iteration, the corrected pt is used for the kinematic cuts like muon pt cut or mass cut.

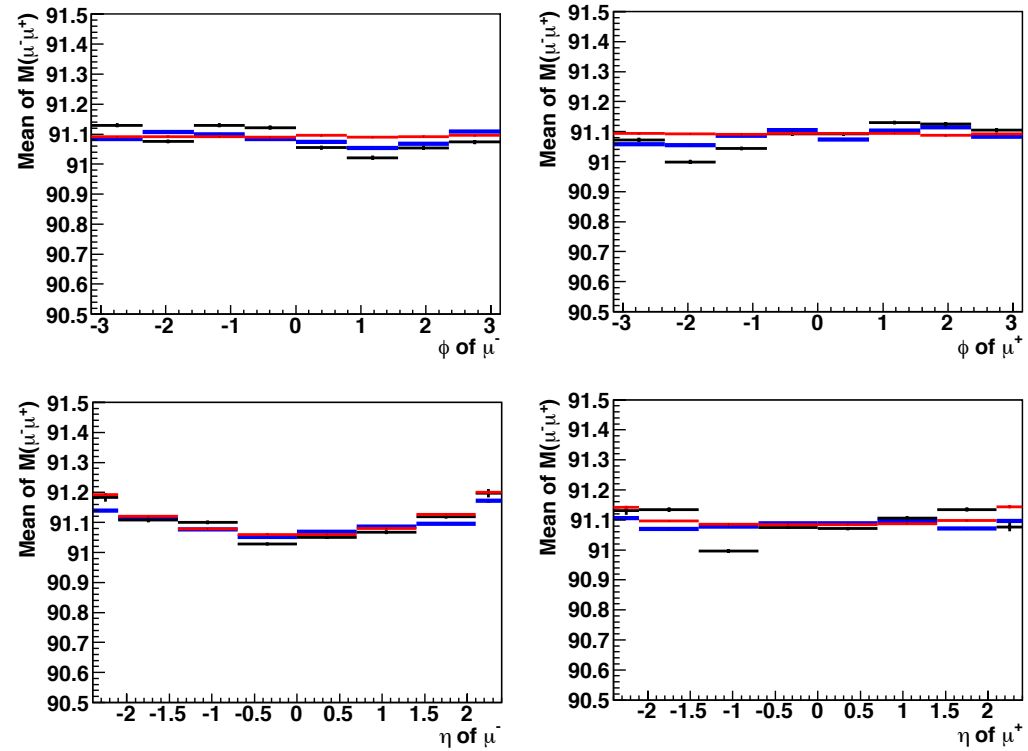
Q2) How do we extract the random uncertainty from dM/M distribution and how to translate it to dpt/pt ?

- To derive the random uncertainty from dM/M, we estimated the additional correction factor "Acor" using the Z mass in (η, ϕ)
  - corrected p_T = Acor * p_T

    where p_T is after rochester standard correction
  - "Acor" is calculated using the Z mass ratio of gen. M to rec. M
  - Iterate the procedure of getting "Acor" until dM/M is not improved further
- "Acor" is propagated into $<1/p_T>$ correction comparing $<1/p_T>$ after rochester standard correction with $<1/p_T>$ after rochester standard correction + "Acor"
- The shift of $<1/p_T>$ correction corresponds to the random uncertainty from the mass difference

Z mass profile in 2011A data



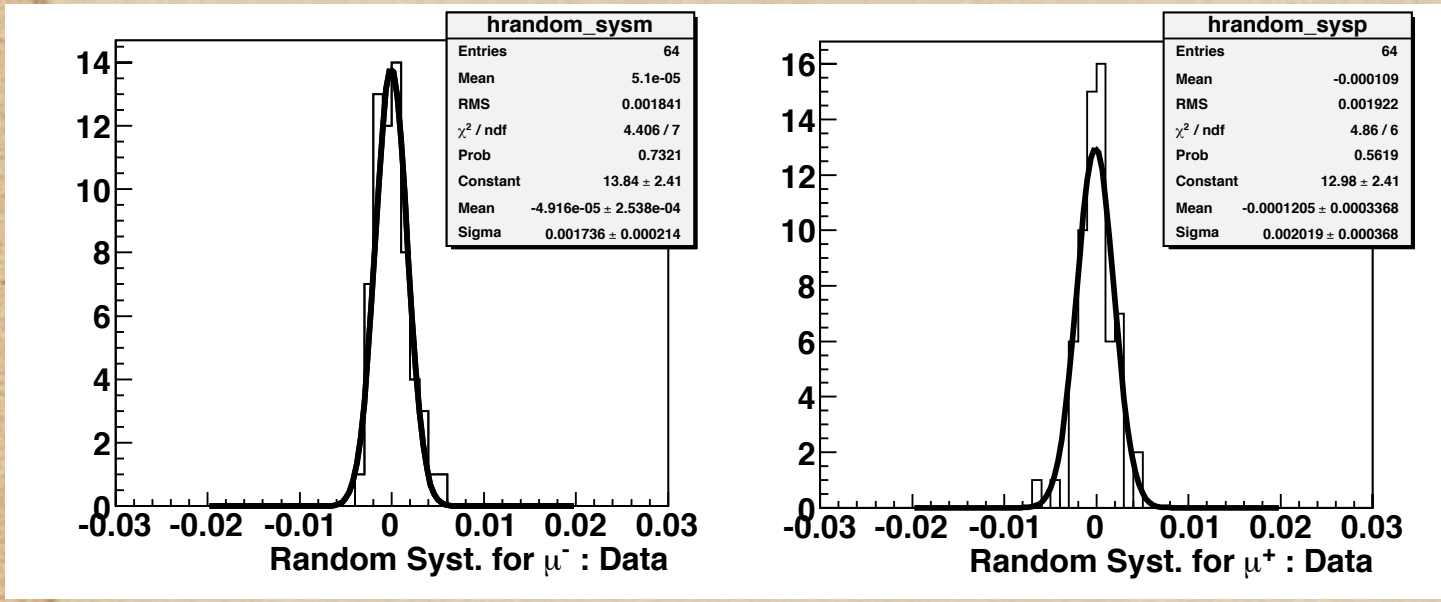


Z mass profile for data (black) and MC (blue) with no correction.
It should be equal to red (Gen.)
Bias between plus and minus in η and ϕ

Z mass profile for data (black) and MC (blue) after rochester correction
It should be equal to red (Gen.). Bias removed
However, random scatter in corrected data (but not corrected MC) because p_T dependence of efficiency vs. η in MC is not same as in data
Effect is larger in 2011B data set

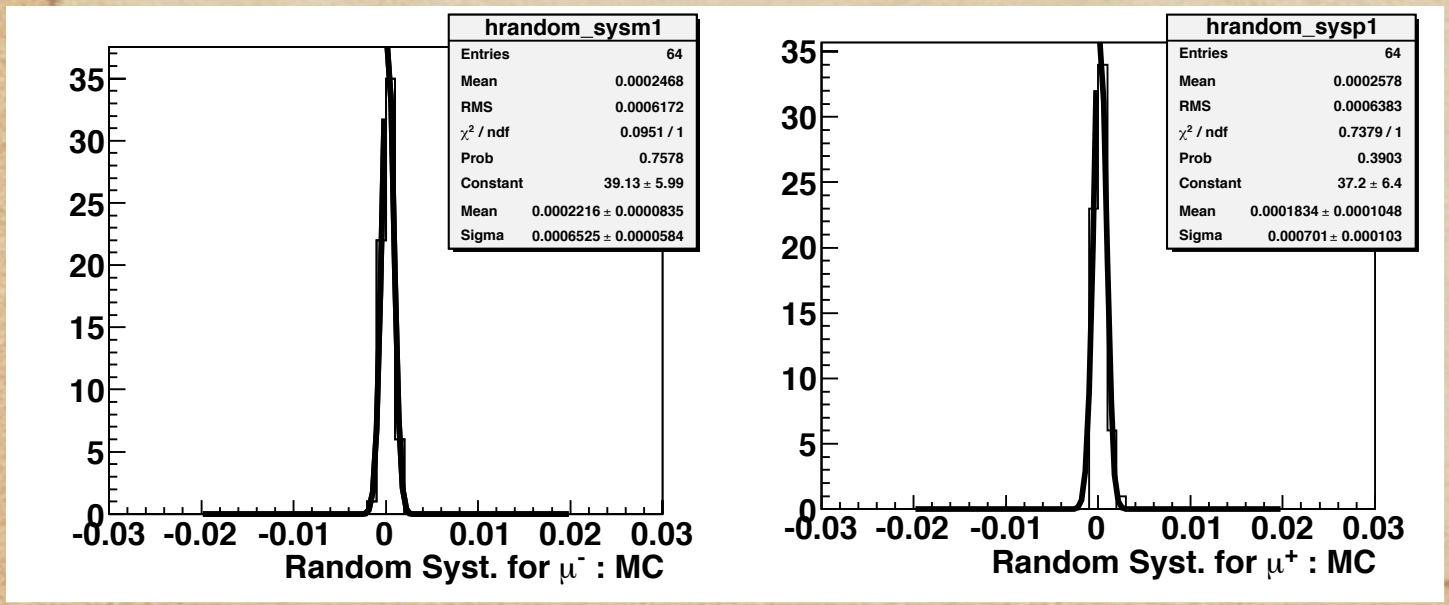
dM/M distribution in 2011A

- Plot dM/M distribution to see the effect after rochester correction
  - Fit dM/M using gaussian distribution



dM/M after rochester correction in data

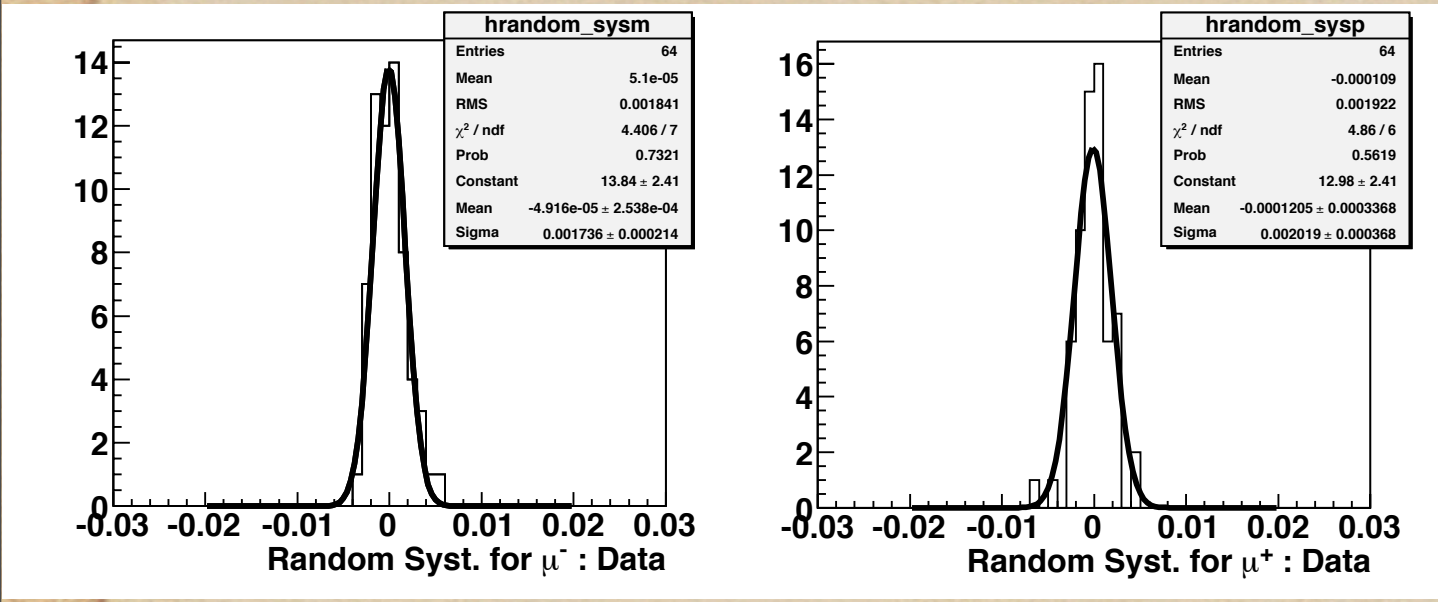
0.2 % RMS in Z mass



dM/M after rochester correction in MC

0.07 % RMS in Z mass

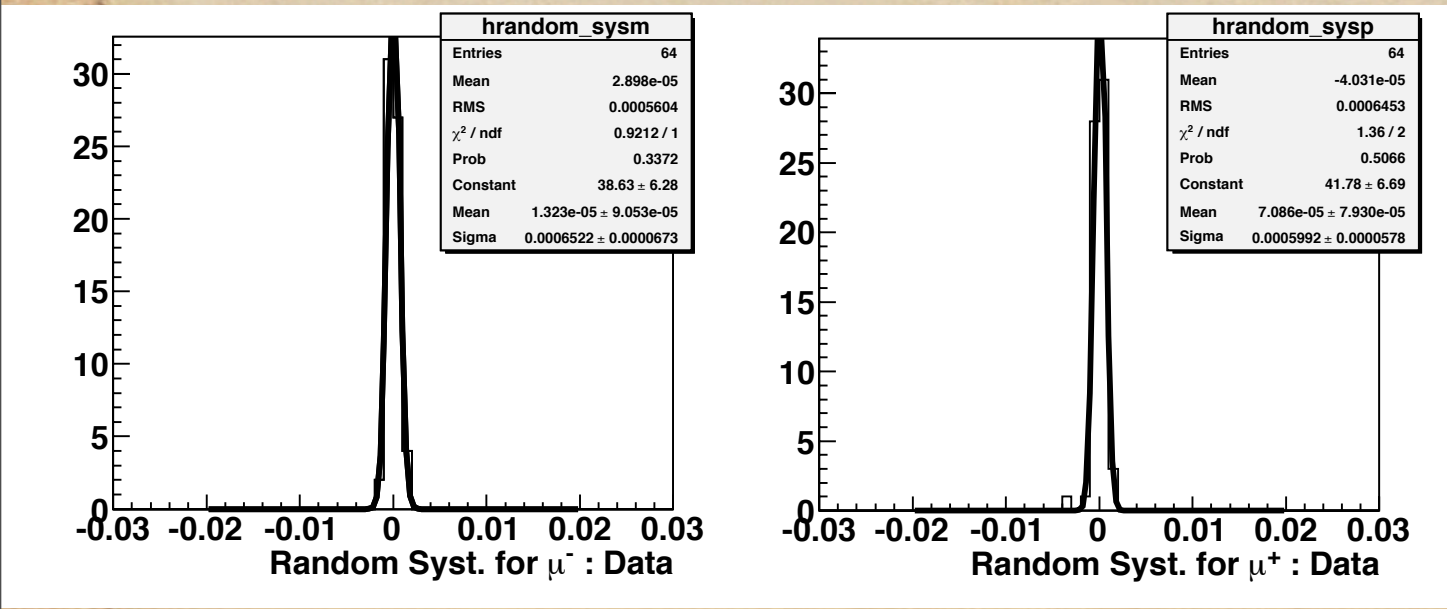
dM/M in 2011A after additional correction



dM/M after rochester correction only in data

0.2 % RMS in Z mass

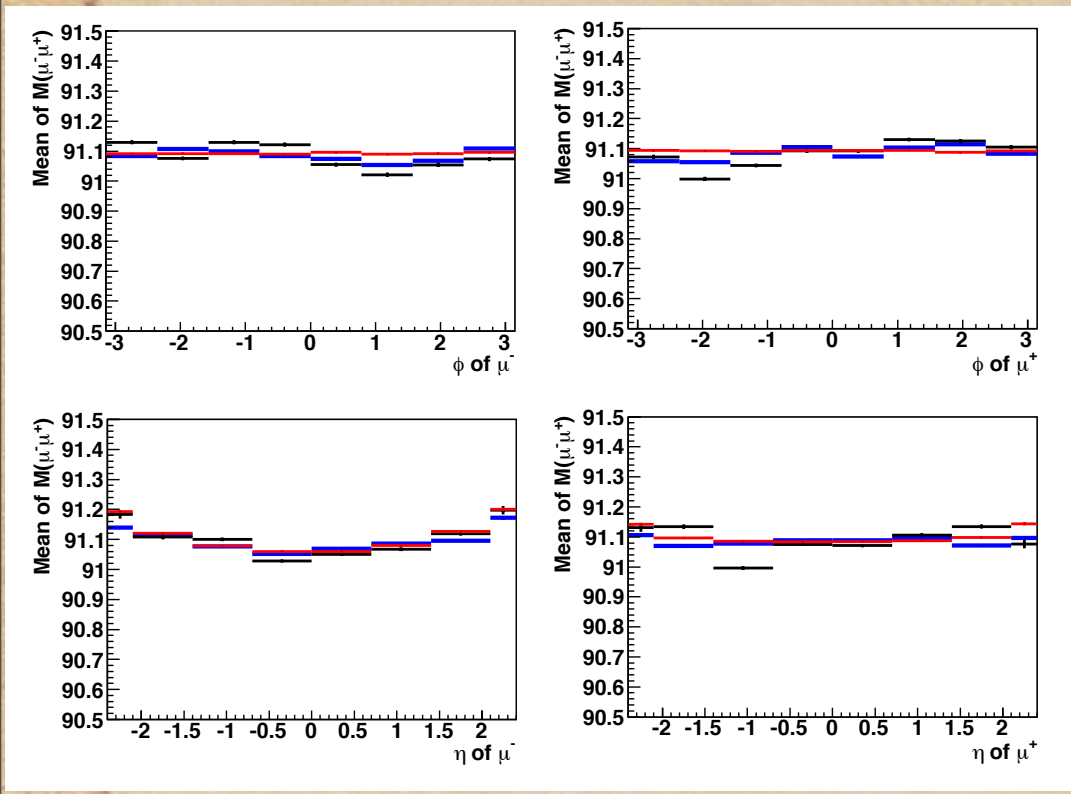
(Same one with previous page)



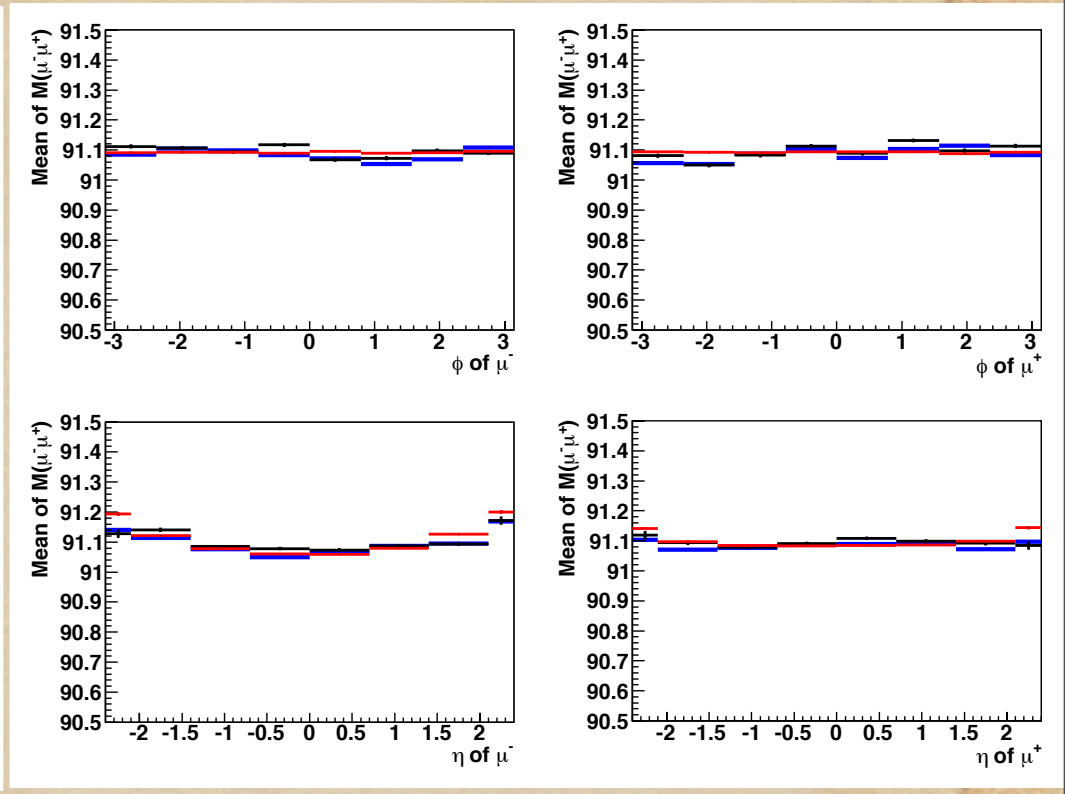
dM/M after rochester correction + additional correction propagated from Z mass in data

0.06 % RMS in Z mass

Z mass profile after additional correction : 2011A



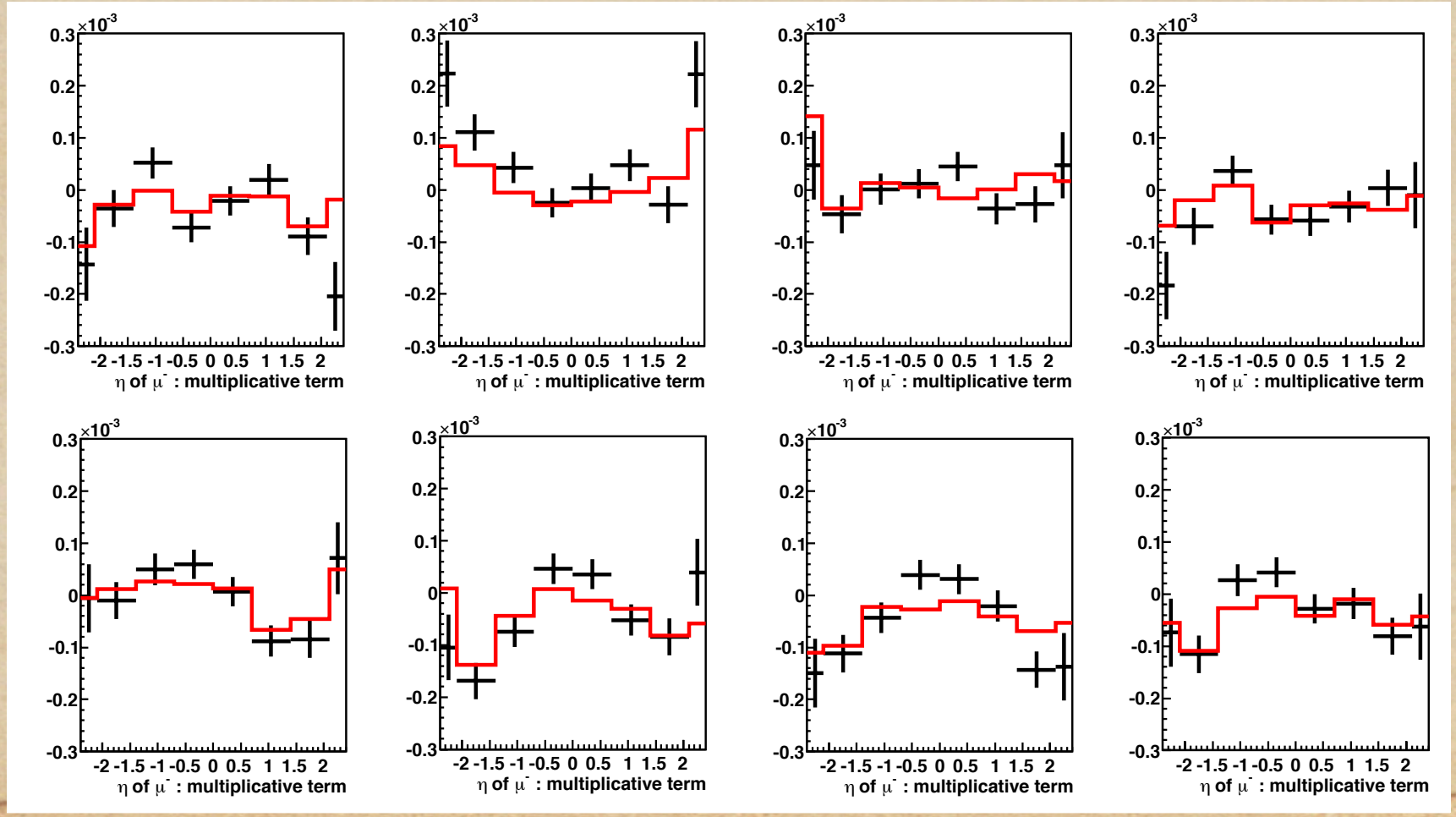
Z mass profile after rochester correction in 2011A data



Z mass profile after rochester correction + additional correction propagated from Z mass in 2011A data

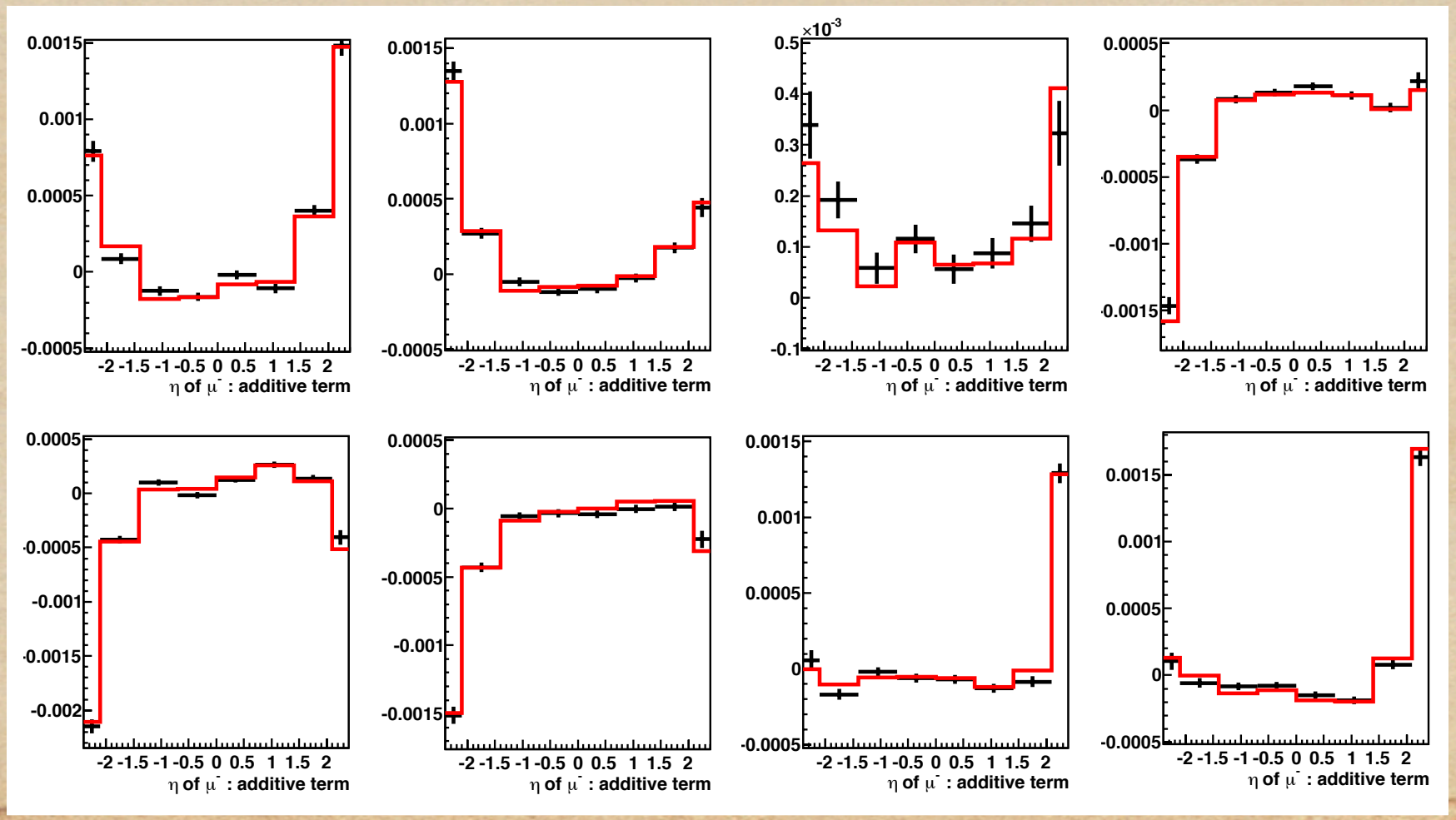
$<1/p_T>$ correction shift in Dm (multiplicative part)

- Compare $<1/p_T>$ correction between standard vs. standard+shift
  - shift is propagated from the additional correction using Z mass
  - Black : standard $<1/p_T>$ correction for 2011A data
  - Red : standard $<1/p_T>$ correction + shift



$<1/p_T>$ correction shift in Da (additive part)

- Compare $<1/p_T>$ correction between standard vs. standard+shift
  - shift is propagated from the additional correction using Z mass
  - Black : standard $<1/p_T>$ correction for 2011A data
  - Red : standard $<1/p_T>$ correction + shift



Translation dM/M into dp/p

- dM/M is calculated in each η and ϕ bin
  - Each dM is dominated only by one cell of probe leg because the other leg is averaged in all η and ϕ range and the average is zero

Start with the equation : $M^2 = 2E_1 \times E_2 \times (1 - \cos\theta)$

$$2MdM = 2dE_1 \times E_2 \times (1 - \cos\theta) = \frac{dE_1}{E_1} \times (2E_1 \times E_2 \times (1 - \cos\theta) = \frac{dE_1}{E_1} \times M^2$$

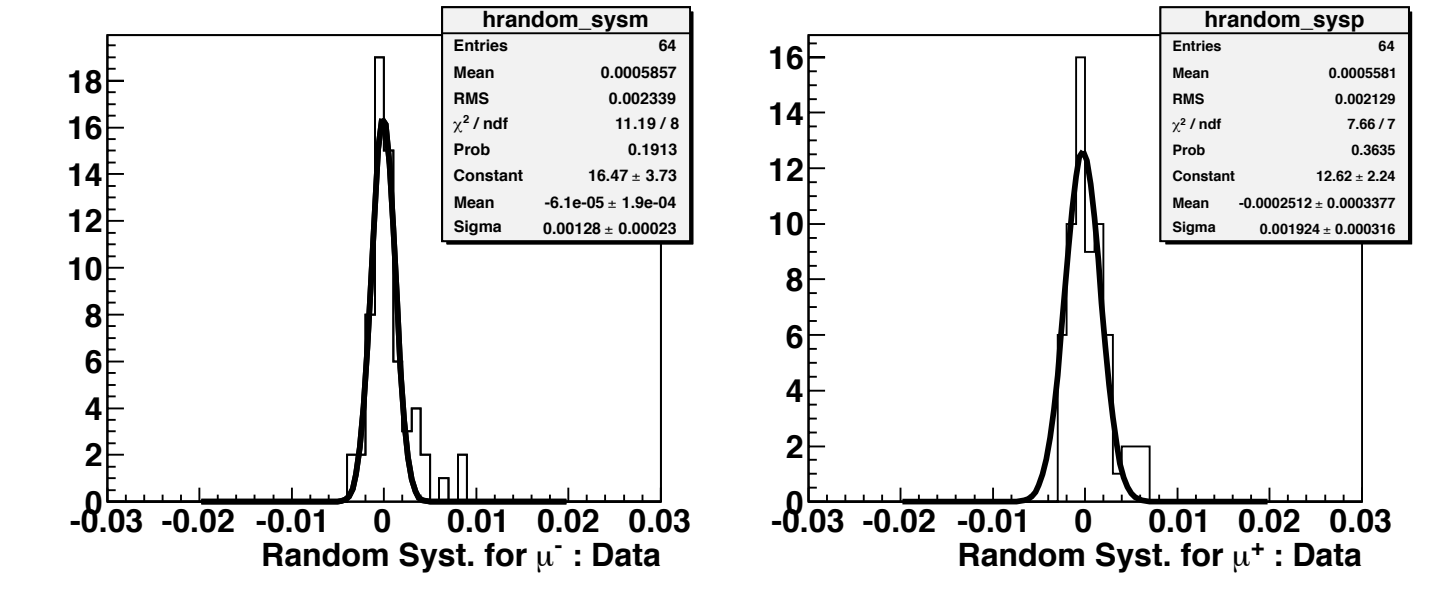
Divide by $M^2 \Rightarrow$ $2 \times \frac{dM}{M} = \frac{dE_1}{E_1}$

- Therefore, 0.06 % RMS in Z mass corresponds to 0.12% RMS in $p_T(\mu)$
- 0.06% RMS in Z mass is reduced to 0.03% RMS with 1.5*shift
  - This corresponds to 0.06% RMS on $p_T(\mu)$

- Same study is performed for 2011B data set
  - Next 4 slides corresponds to 2011B data set

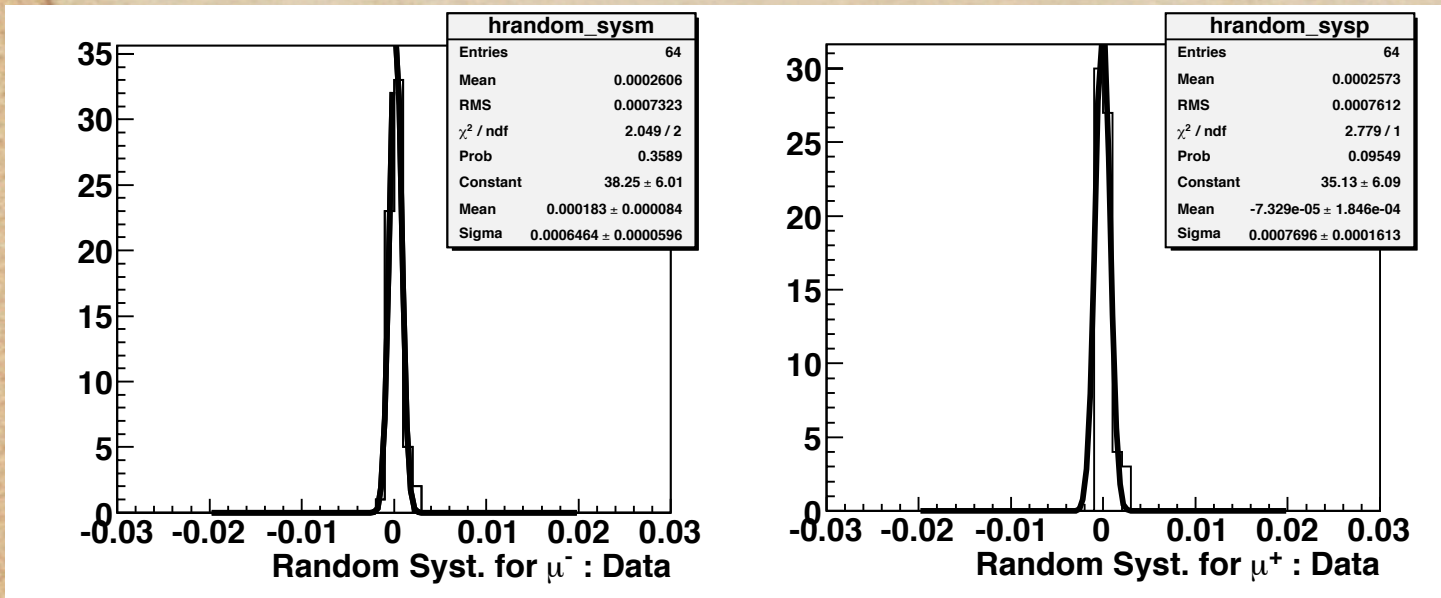
dM/M distribution in 2011B data

- Plot dM/M distribution to see the effect after rochester correction
  - Fit dM/M using gaussian distribution



dM/M after rochester correction in data

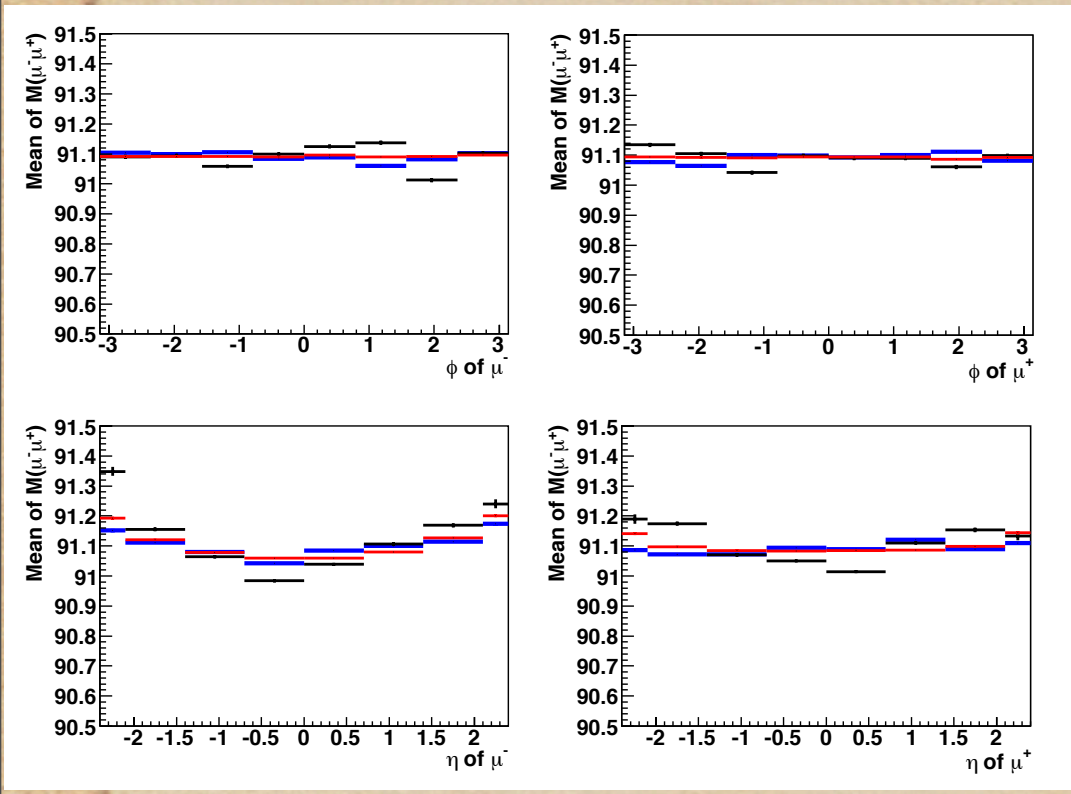
0.2 % RMS in Z mass



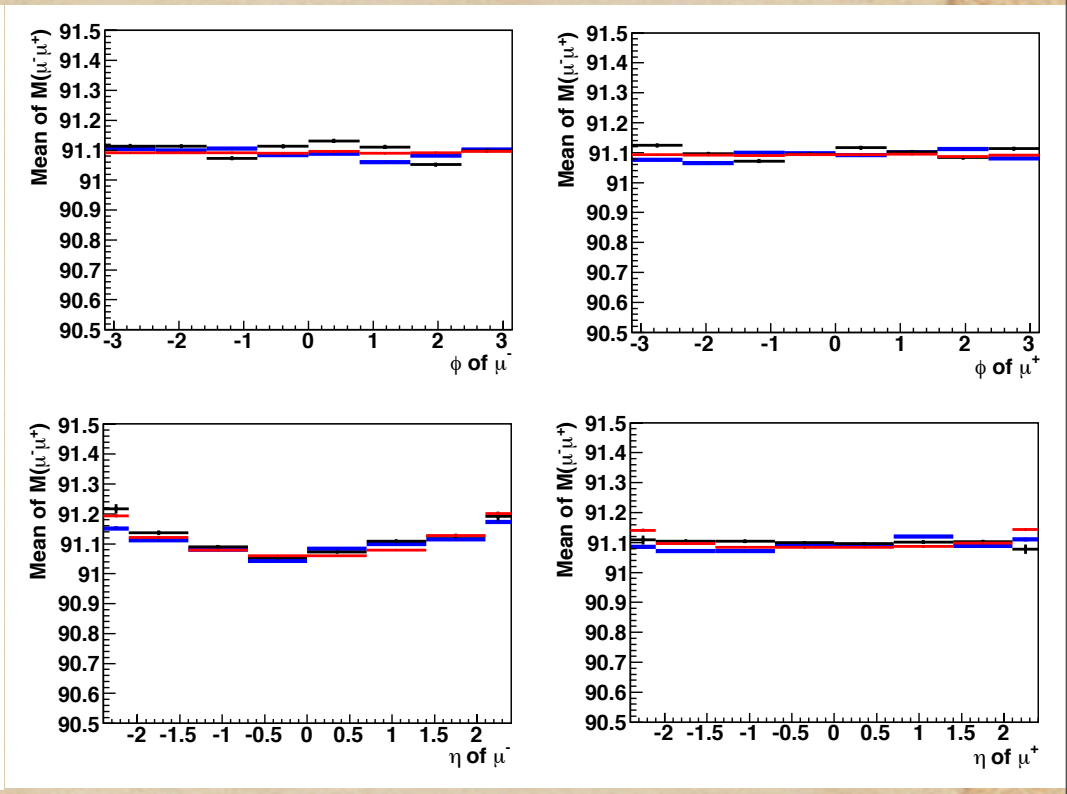
dM/M after rochester correction in MC

0.07 % RMS in Z mass

Z mass profile after additional correction : 2011B



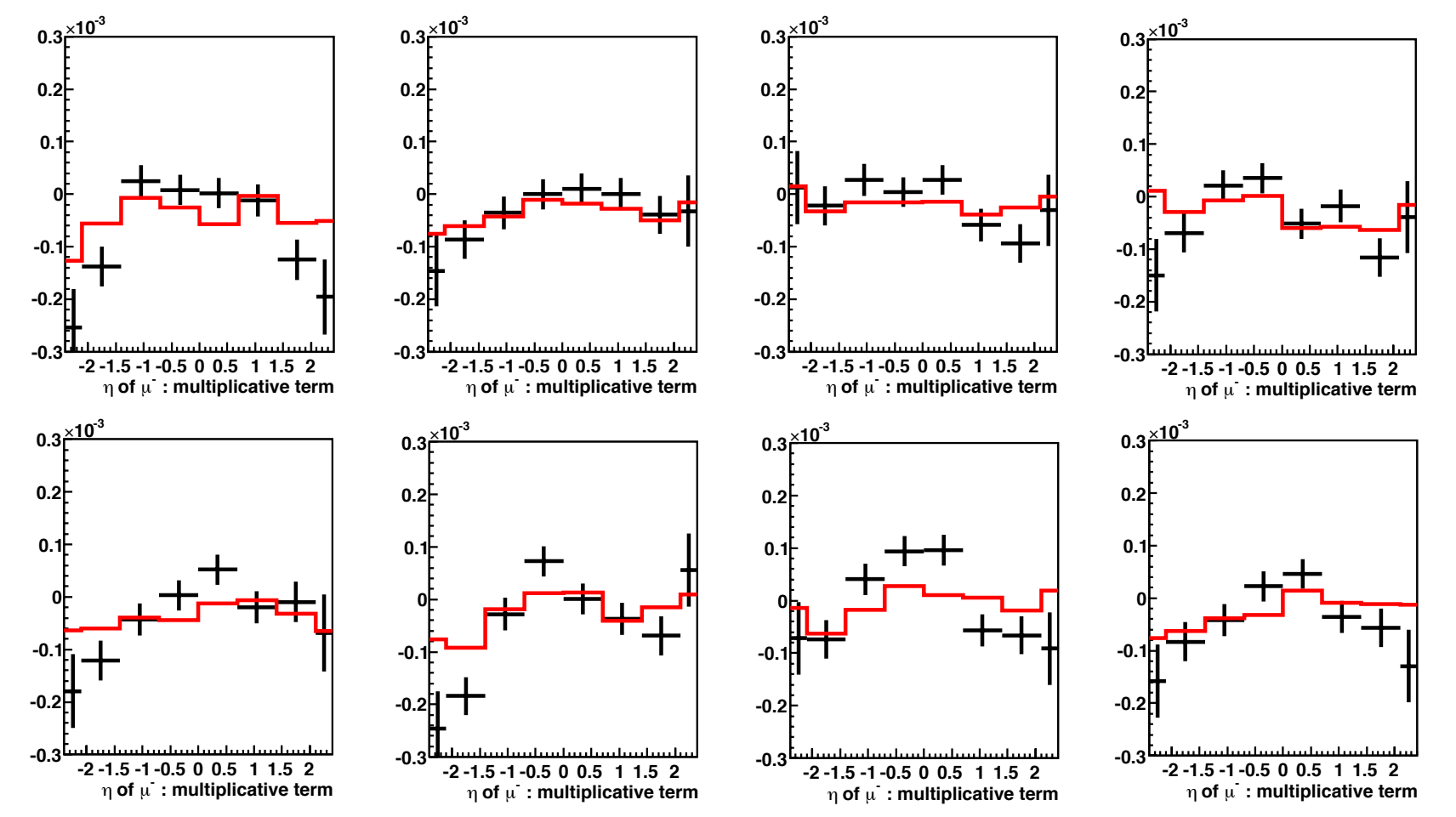
Z mass profile after rochester correction in 2011B data



Z mass profile after rochester correction + additional correction propagated from Z mass in 2011B data

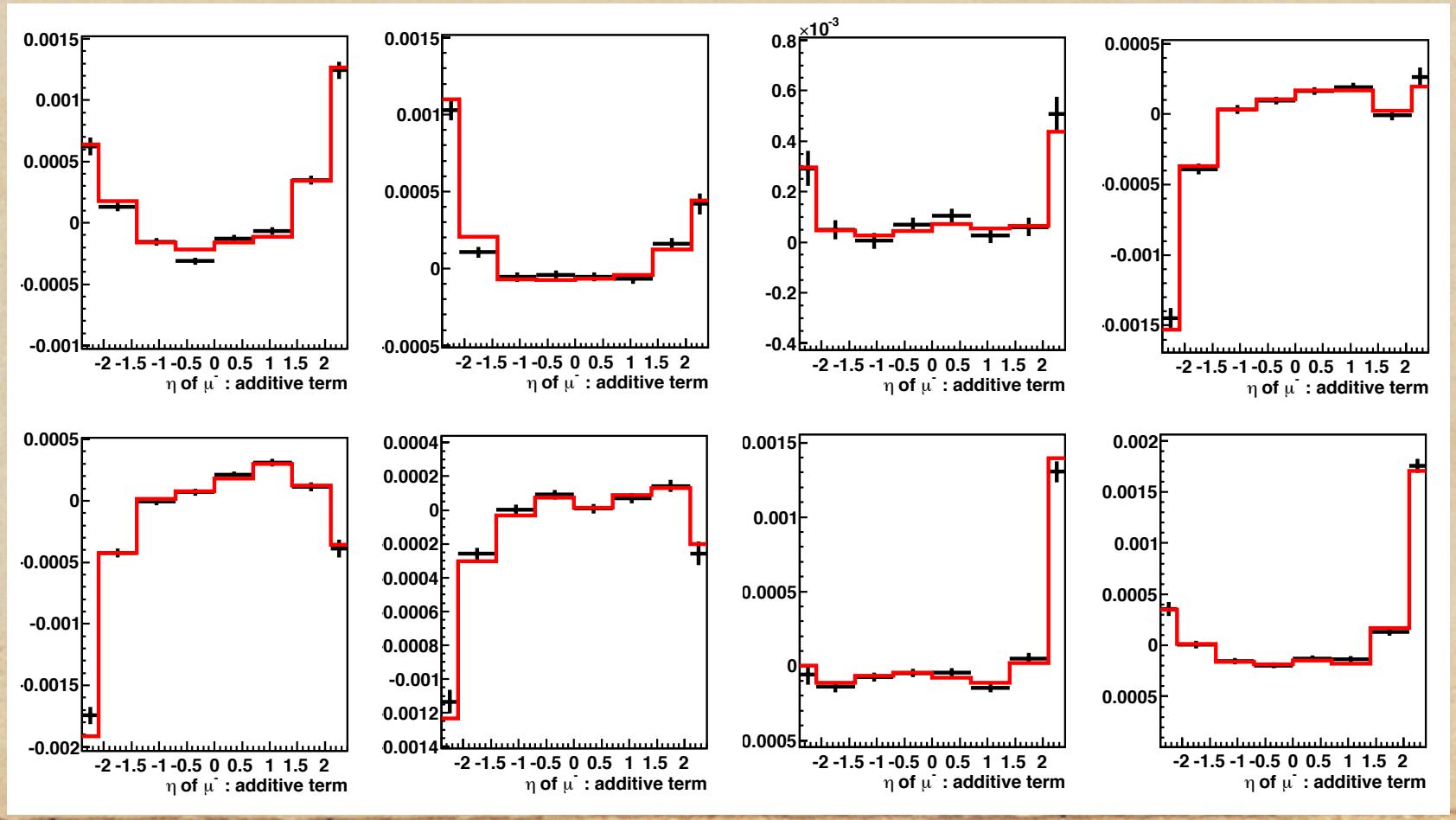
$<1/p_T>$ correction shift in Dm for 2011B

- Compare $<1/p_T>$ correction between standard vs. standard+shift
  - shift is propagated from the additional correction using Z mass
  - Black : standard $<1/p_T>$ correction for 2011B data
  - Red : standard $<1/p_T>$ correction + shift



$<1/p_T>$ correction shift in Da for 2011B

- Compare $<1/p_T>$ correction between standard vs. standard+shift
  - shift is propagated from the additional correction using Z mass
  - Black : standard $<1/p_T>$ correction for 2011B data
  - Red : standard $<1/p_T>$ correction + shift



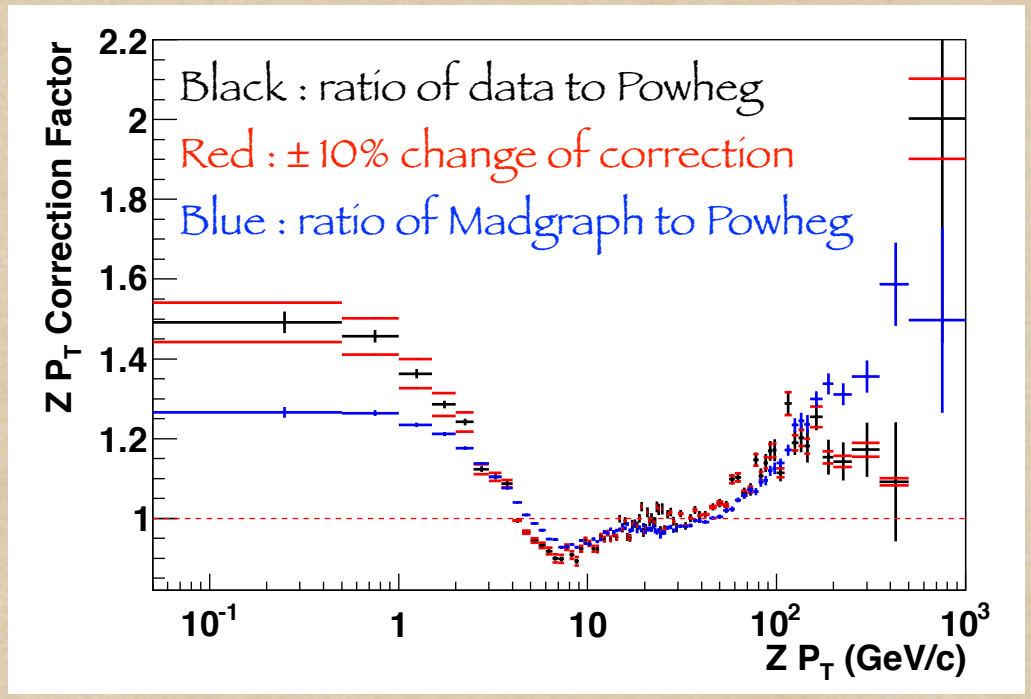
Conclusion for random systematics

- Random systematic error is propagated using the additional correction from Z mass
- dp/p (fractional error of μ momentum) corresponds to 2xdM/M
- Random systematic error in $<1/p_T>$ correction is 0.12 %
  - 2011A and 2011B has the same level
  - Overall bias is zero
  - Origin is that the modeling of efficiencies in MC is not perfect
- Random systematic error in $<1/p_T>$ correction as a function of (η, ϕ)
  - The shift of $<1/p_T>$ correction can be assigned as systematic error
  - This shift can be used for better precise correction
- The error can be reduced from 0.4% to 0.12% random error of dp/p if tuned coefficients using η/ϕ dependence of Z mass are used

*** We recommend that the combined $<1/p_T>$ and dM/M coefficients become the standard if the random error on dp/p is to be reduced to 0.12 %

Q3) Systematic uncertainty for Z Pt correction

- The systematic uncertainty of Z Pt correction is assigned using 10% change of the correction
- Requested to compare Z Pt from Madgraph



- The correction of Z Pt using Madgraph is lower than data
- Confirmed Z Pt correction used (black) is consistent with the published 2010 measurement
  - ± 10% assignment for syst. error is reasonable
  - The systematic error using Madgraph might be over-estimated