Summary of Z rapidity measurement

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Introduction

- PDFs constraint
  - ZY is determined by the difference between the energies of the initial state quarks
  - ZY measurement at Tevatron constrains valence quark PDF (u and d)
  - Large x range (ZY up to 1.6, x up to 0.2) $x = \frac{M_Z}{\sqrt{s}} \times e^{\pm Y_Z}$

Data and MC samples

- Run IIb 8.6 fb^{-1} data (selected data~400k)
- Signal MC: Pythia Zmumu events for unfolding study

Measurement Strategy

Event selection

- Two well isolated muons selected
- Mass window [74,110] GeV
- pT>15GeV, |eta|<1.6, opposite sign

Corrections

- Muon momentum calibration
- Efficiency (selection + trigger)
- Additional efficiency correction

Background subtracted

- EW: from MC
- Multi-jet: data driven

Unfolding

- Migration: matrix method
- Acceptance

Systematic uncertainty

- Consider bin-by-bin correlation

Event selection

- Muon selection
  - pT>15GeV, |eta|<1.6
  - Standard nseg>0
  - Spatial matched track

    1. Track fit $\chi 2$/d.o.f < 4

    2. DCA < 0.012/0.2 cm if number of SMT hits nSMT > 0/=0

    3. track |dz| < 1.0/1.5/2.0 cm if both two tracks have nSMT >= 2 / only one tracks has nSMT >= 2 / both tracks have nSMT < 2;
  - Trk iso < 0.4, cal iso < 0.4

Event selection

- Opposite charge
- Cos θ_{12} > -0.99985, to remove cosmic ray
- Mass window [74,110] GeV

Corrections

Muon momentum correction

- Pre-scale and pre-smear
  1. standard correction function
  2. separate solenoid +/- events

if $U(0,1) > C$

$$\frac{q}{p_T} \to \frac{q}{p_T} \times S + \left(\frac{R_{\rm CFT}}{L}\right)^2 \times \left(A \times N(0,1) + B \times N(0,1) \times \frac{\sqrt{\cosh(\eta)}}{p_T}\right)$$

if $U(0,1) < C$

$$\frac{q}{p_T} \to \frac{q}{p_T} \times S + \left(\frac{R_{\rm CFT}}{L}\right)^2 \times \left(D \times N(0,1) + B \times N(0,1) \times \frac{\sqrt{\cosh(\eta)}}{p_T}\right)$$

	S	A($\times 10^{-3}$)	B($\times 10^{-2}$)	C($\times 10^{-2}$)	D($\times 10^{-3}$)
solenoid > 0	1.00262	1.74	1.010	5.02	6.14
solenoid < 0	1.00191	1.75	1.020	5.23	6.03

- Charge-eta dependent calibratio $P = \alpha(\eta, q, \mathrm{sol}) P_{\rm obs}$
  1. separate for solenoid +/-
  2. separate for data and MC

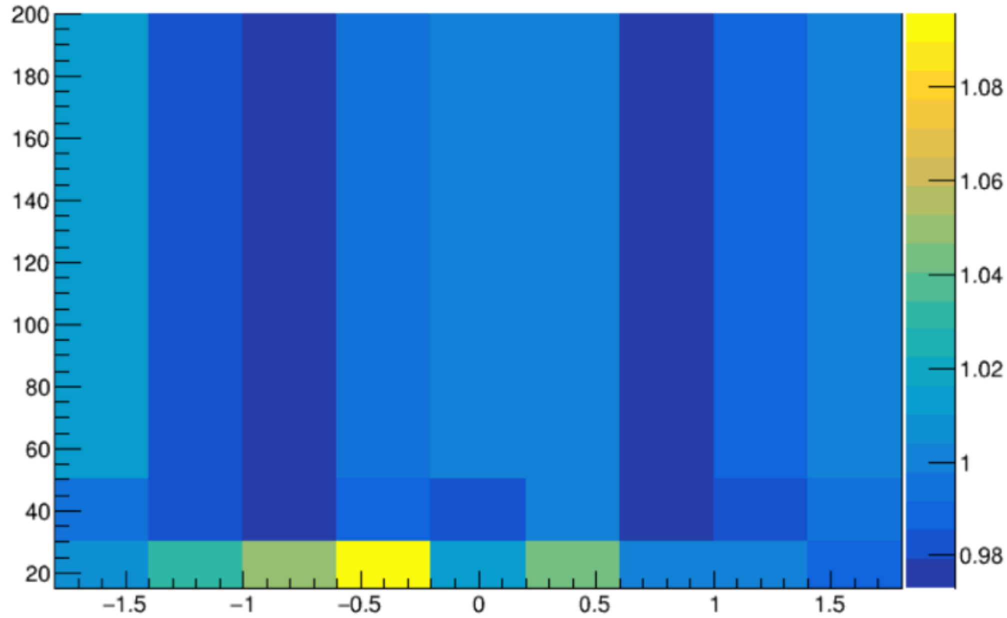
Corrections

Trigger efficiency

- Standard combined muon trigger efficiencies from caf_trigger package

Selection efficiency

- Combine id, track quality and isolation efficiencies
- Tag-and-probe
- 2D: muon eta and muon pT



Corrections

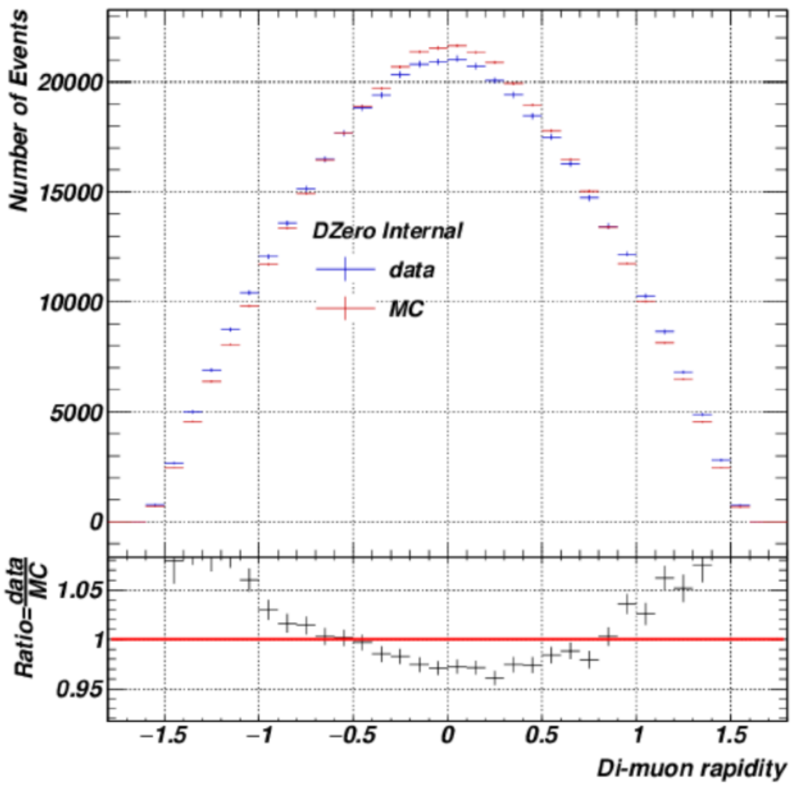
Overall efficiency estimation

	+eta	-eta
0-0.2	1	1
0.2-0.6	1.0116 ± 0.0380	1.0227 ± 0.0397
0.6-1.0	1.0451 ± 0.0453	1.0452 ± 0.0453
1.0-1.4	1.0290 ± 0.0434	1.0461 ± 0.0463
1.4-1.8	1.0232 ± 0.0952	1.0296 ± 0.0976

$$rwt_i^{Eff} = \sqrt{\frac{N_{ii}^{Data} - N_{ii}^{BKG}}{N_{ii}^{MC} * rwt_i^{Theory}} * \frac{N_{11}^{Data} - N_{11}^{BKG}}{N_{11}^{MC} * rwt_1^{Theory}}}$$

Corrections

Data and MC comparison after corrections



Background subtraction

SM EW backgrounds and W + jets

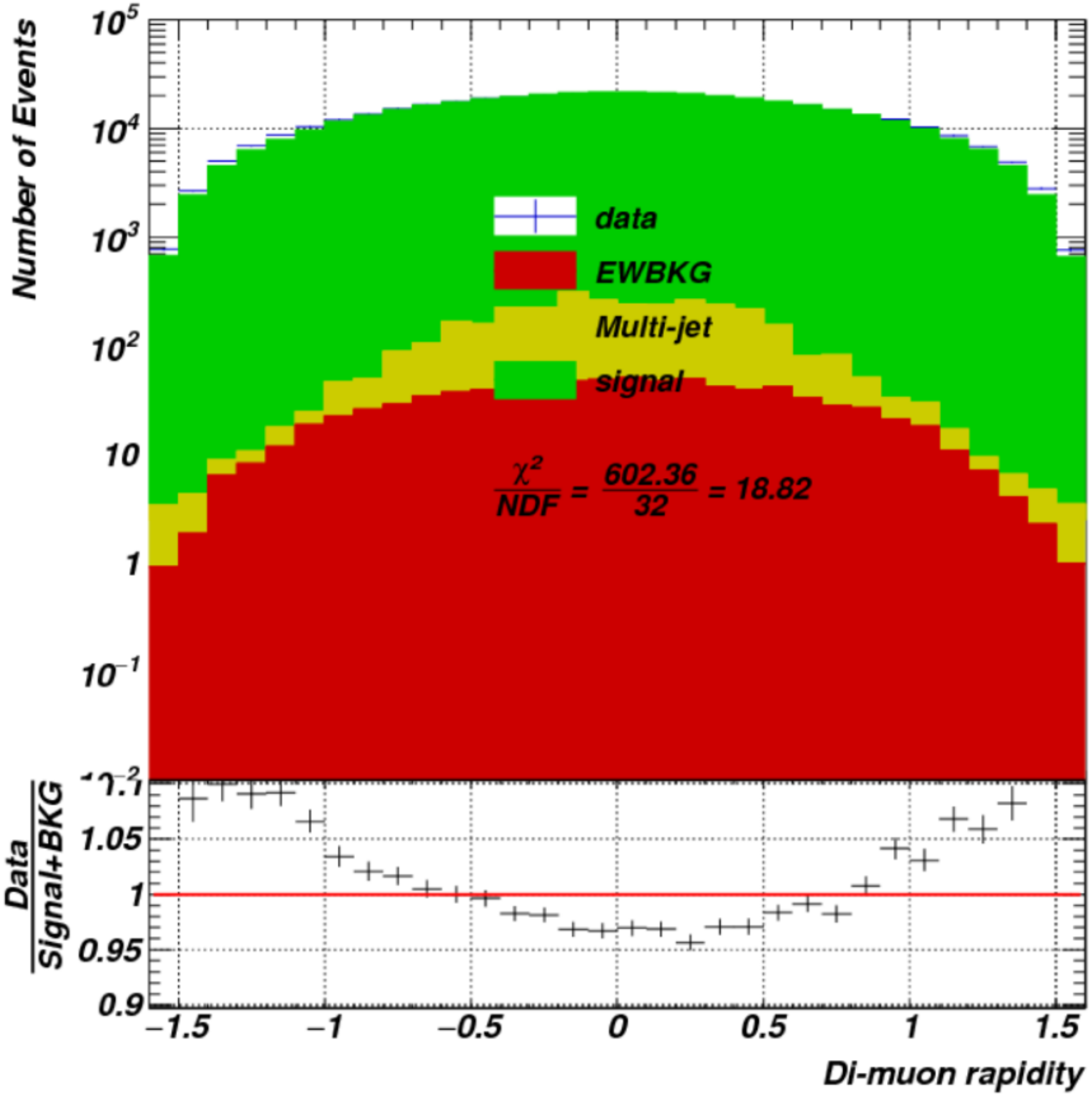
- ttbar, WW, WZ, $Z\tau\tau$, and W + jets
- Estimated using MC simulations
- 0.2% in total

Multi-jet backgrounds

- Estimated from data
- Normalization: same sign events (subtract same sign EW bkg and signal)
- Shape: reversed-isolation selections
- 0.59% in total

Background subtraction

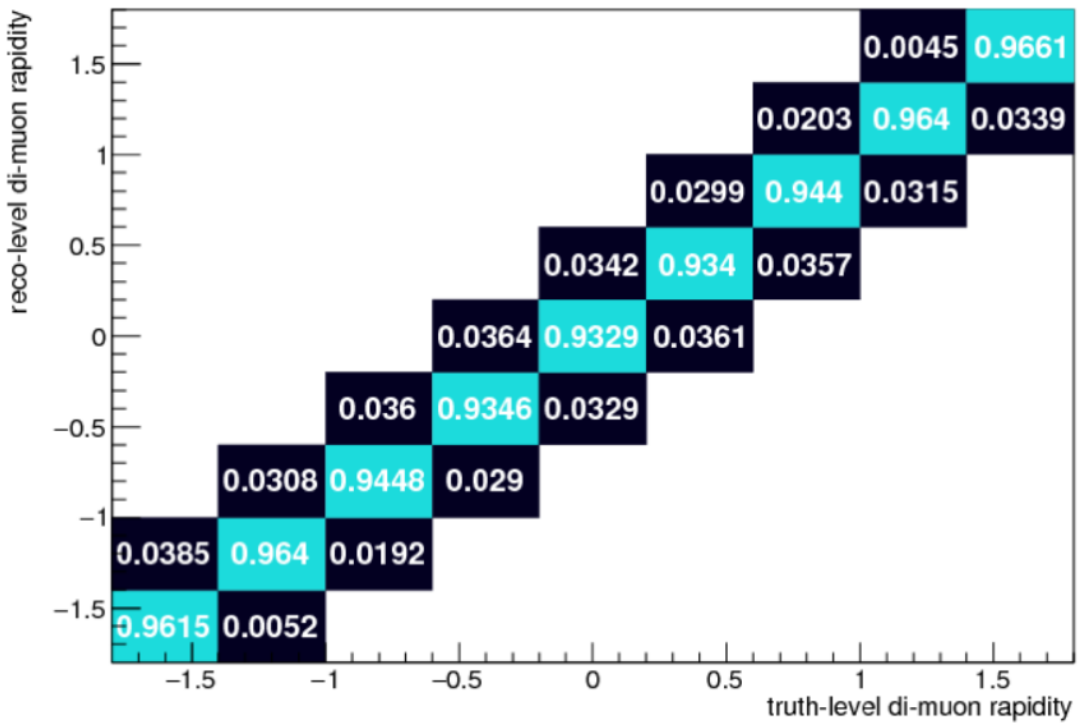
ZY spectrum of di-muon of selected data, signal MC and all backgrounds



Unfolding procedure

Migration

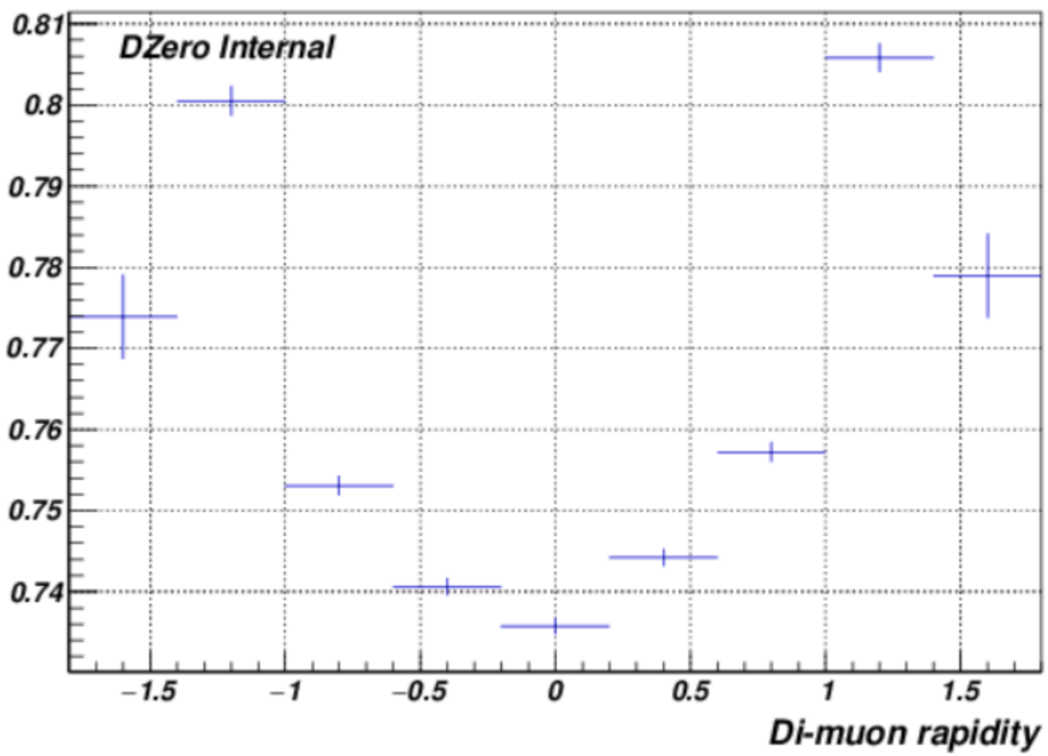
- Using unfolding matrix R to describe migration effect
- Unfolding matrix derived from MC samples
- ZY bin purity >90%
- $N_i^{\mathrm{Data}} = \Sigma_j R_{ij} N_j^{\mathrm{Unfold}}$



Unfolding procedure

Acceptance

- Phase space passing reco-level selections is different from that passing truth-level selections
- Unfold to acceptance of pT>15, |eta|<1.6 and mass window [74, 110] GeV



Systematic uncertainty

Uncertainties from different sources

Statistical uncertainty (~1%)

Muon momentum calibrations (negligible)

- Changing +μ scale by 1.00005 and -μ scale by 0.99995 (0.0001 on charge dependence)
- Changing both +μ and -μ scale by 1.0001 (0.0001 on overall momentum scale)

Background estimation (~1%)

- Changing EW background normalization by 25%
- Changing multi-jet background normalization by 100%

Efficiency corrections (1%~2%)

- Overall scale factor

 1. Statistical uncertainty ~1%

 2. Systematic uncertainty: comparing Pythia and ResBos (different differential cross section modeling)

- Background in the denominator of tag and probe methods: compare result from MC and fitting

Systematic uncertainty

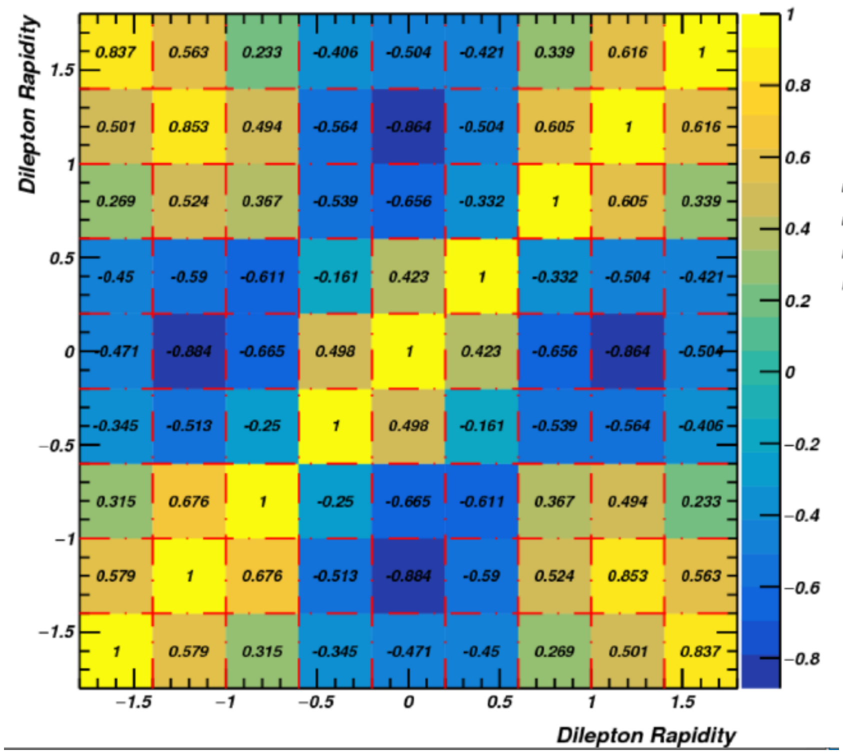
- Correlation matrix
  - Random background in denominator of tag-and-probe
  - Random data, signal MC according to statistical uncertainty
  - Random EW background (25%) and multi-jet background (100%)
  - Reweight $N_{\eta\eta}^{MC}$ to ResBos prediction

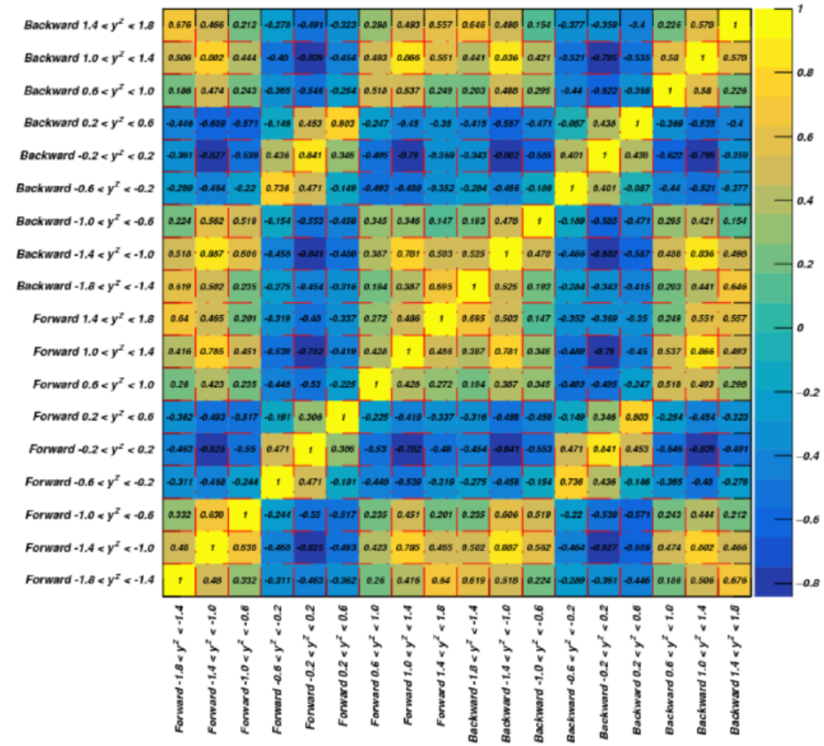
$$rwt_i^{Theory} = 1 + (ratio_i - 1) * Uniform(0,1)$$

  - Remove background
  - Derive overall efficiency factors, and apply it to MC
  - Unfold

Systematic uncertainty

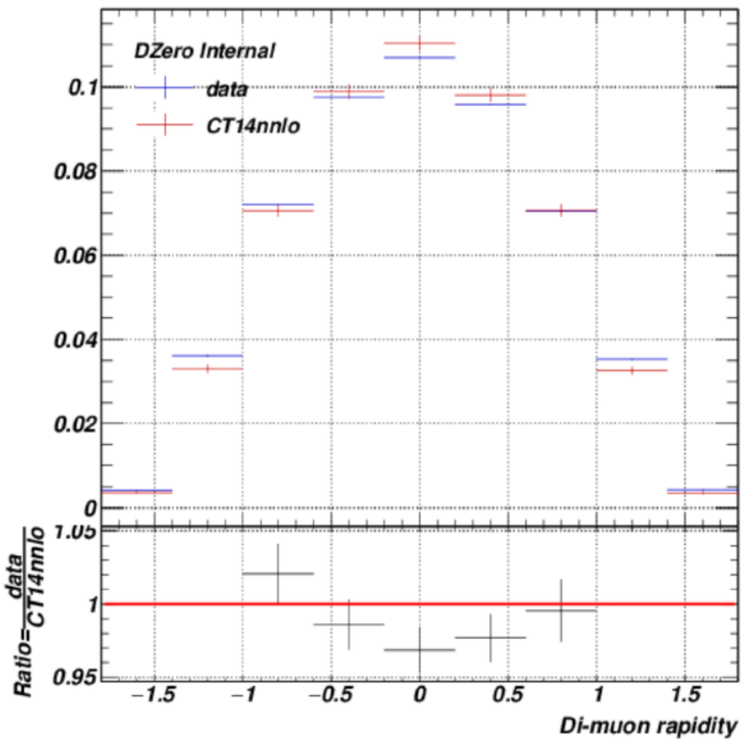
Correlation matrix

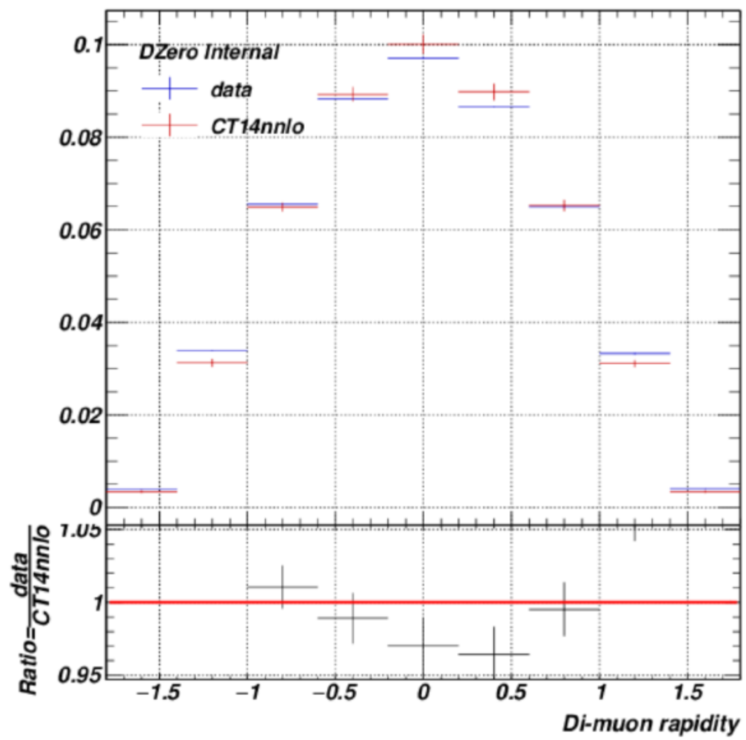




Forward	4.2%	2.2%	0.96%	1.1%	1.2%	1.3%	0.93%	2.2%	4.1%
Backward	4.1%	2.2%	0.86%	1.1%	1.2%	1.3%	0.95%	2.2%	4.2%

Result


DZero Internal
data
CT14nnlo
0.1
0.08
0.06
0.04
0.02
0
1.05
1
0.95
Ratio=data/CT14nnlo
−1.5
−1
−0.5
0
0.5
1
1.5
Di-muon rapidity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1.05
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Ratio=data/CT14nnlo
−1.5
−1
−0.5
0
0.5
1
1.5
Di-muon rapidity

Backup

Background subtraction (data:417582)

ttbar F:37.451 B:37.4133

WW F:49.2362 B:57.1401

WZ F:117.02 B:105.061

Ztaotao_60_130 F:67.1235 B:62.5616

Ztaotao_130_250 F:21.1913 B:7.48212

W0lp F:25.8085 B:27.1432

W1lp F:65.3661 B:60.4892

W2lp F:32.9414 B:32.9649

W3lp F:13.0868 B:13.0227

W4lp F:5.34196 B:4.20592

W2b0lp F:0.757737 B:0.498956

W2b1lp F:0.748773 B:0.533777

W2b2lp F:0.363674 B:0.377939

W2b3lp F:0.295319 B:0.1674

W2c0lp F:0.713144 B:0.547271

W2c1lp F:1.38015 B:1.28825

W2c2lp F:0.906719 B:1.08869

W2c3lp F:0.563407 B:0.651887

Total 852.934

QCD 2477.34