

Resolution recommendation for high p_T muons

Muon POG Meeting

03/15/21

Alice

General

- High pT calibration started at the beginning of Run 2 within the Zprime and Wprime analysis
- Systematic studies did not exist in Run 1 (low statistics)
- The current muon POG recommendations are then mostly derived from the need of two analyses
- The High pT paper was dedicated to understand the various performance aspects of the high pT muons but not to give prescriptions for analysis
- Few muon experts and most of the analyses using high pT muons are using the prescriptions like a black box

Conclusion: the recommendation have to be very precise and adapted for general cases

Thank you to Daniele for pointing us to the sub-optimal resolution treatment and for the discussion (also with Jan) for coming to a better proposal

Current recommendation

- Direct comparison of the single muon p_T resolution between cosmic data and DY MC:
 - Detailed description can be found in [AN-2018/008](#)
 - For the 3 years we observe a very good agreement up to $|\eta| = 1.2$, no specific treatment to the MC needs to be done, [plots](#).
- Dimuon mass resolution using boosted Z events in data and MC that allows to probe $|\eta| > 1.2$
 - Detailed description can be found in [AN-2018/008](#)
 - 2018 reference results
 - Extra smearing factors:
 - BB (both muons with $|\eta| < 1.2$): no extra smearing
 - BE+EE (at least one muon with $|\eta| > 1.2$): 15%
 - Systematic uncertainties on the resolution (dominated by binning variation): 10%
 - 2017 reference results
 - Extra smearing factors:
 - BB (both muons with $|\eta| < 1.2$): no extra smearing
 - BE+EE (at least one muon with $|\eta| > 1.2$): 15%
 - Systematic uncertainties on the resolution (dominated by binning variation): 10%
 - 2016 reference results
 - Extra smearing factors:
 - BB (both muons with $|\eta| < 1.2$): no extra smearing
 - BE+EE (at least one muon with $|\eta| > 1.2$): no extra smearing
 - Systematic uncertainties on the resolution (dominated by binning variation): 10%

Issues

Seems to target single muon topology

- Direct comparison of the single muon p_T resolution between cosmic data and DY MC:
 - Detailed description can be found in [AN-2018/008](#)
 - For the 3 years we observe a very good agreement up to $|\eta| = 1.2$, no specific treatment to the MC needs to be done, [plots](#).

Problems: No recommendations for endcaps and no systematics in barrel

- Dimuon mass resolution using boosted Z events in data and MC that allows to probe $|\eta| > 1.2$
 - Detailed description can be found in [AN-2018/008](#)
 - 2018 reference results
 - Extra smearing factors:
 - BB (both muons with $|\eta| < 1.2$): no extra smearing
 - BE+EE (at least one muon with $|\eta| > 1.2$): 15%
 - Systematic uncertainties on the resolution (dominated by binning variation): 10%
 - 2017 reference results
 - Extra smearing factors:
 - BB (both muons with $|\eta| < 1.2$): no extra smearing
 - BE+EE (at least one muon with $|\eta| > 1.2$): 15%
 - Systematic uncertainties on the resolution (dominated by binning variation): 10%
 - 2016 reference results
 - Extra smearing factors:
 - BB (both muons with $|\eta| < 1.2$): no extra smearing
 - BE+EE (at least one muon with $|\eta| > 1.2$): no extra smearing
 - Systematic uncertainties on the resolution (dominated by binning variation): 10%

Specific to dimuon signature

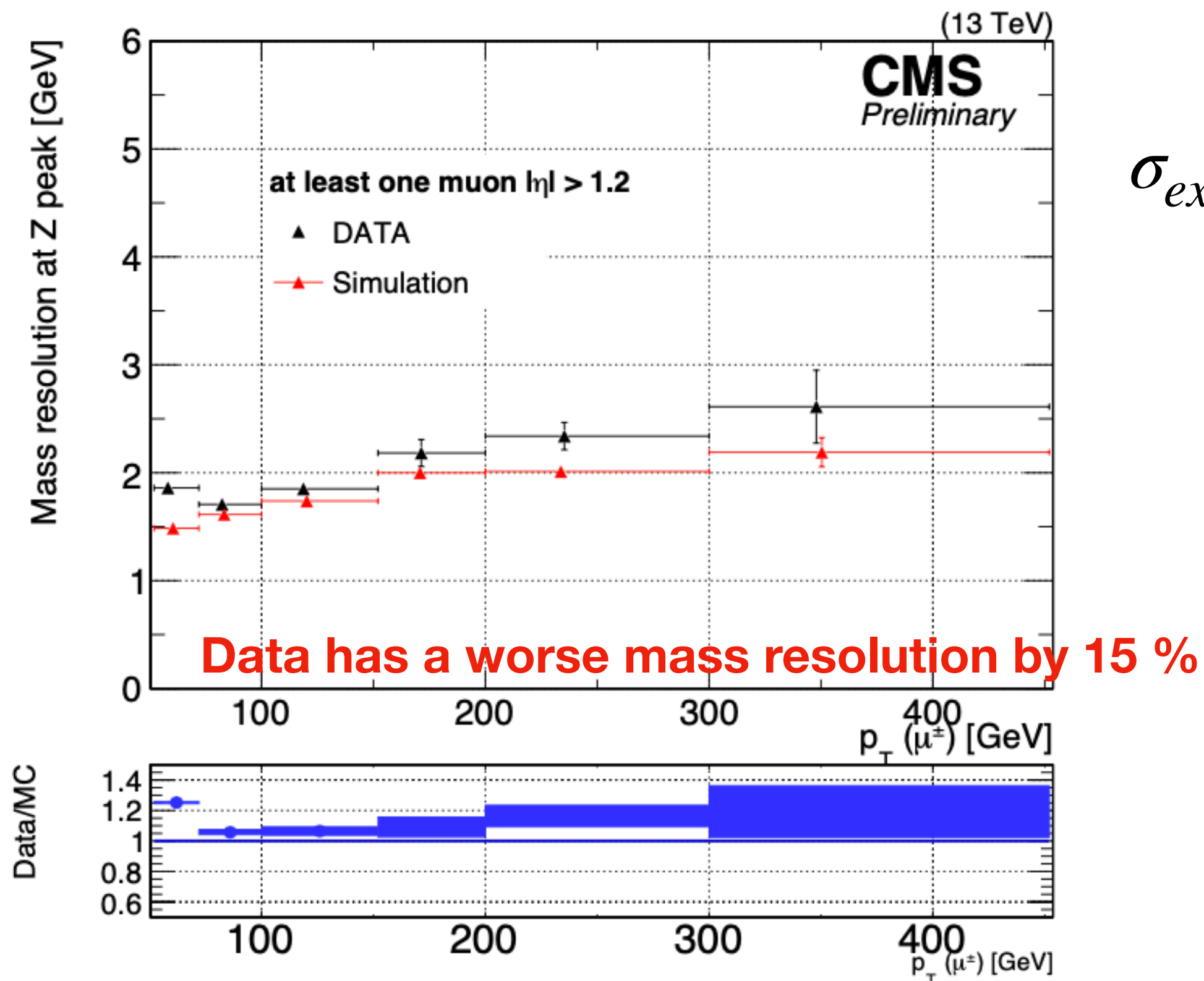
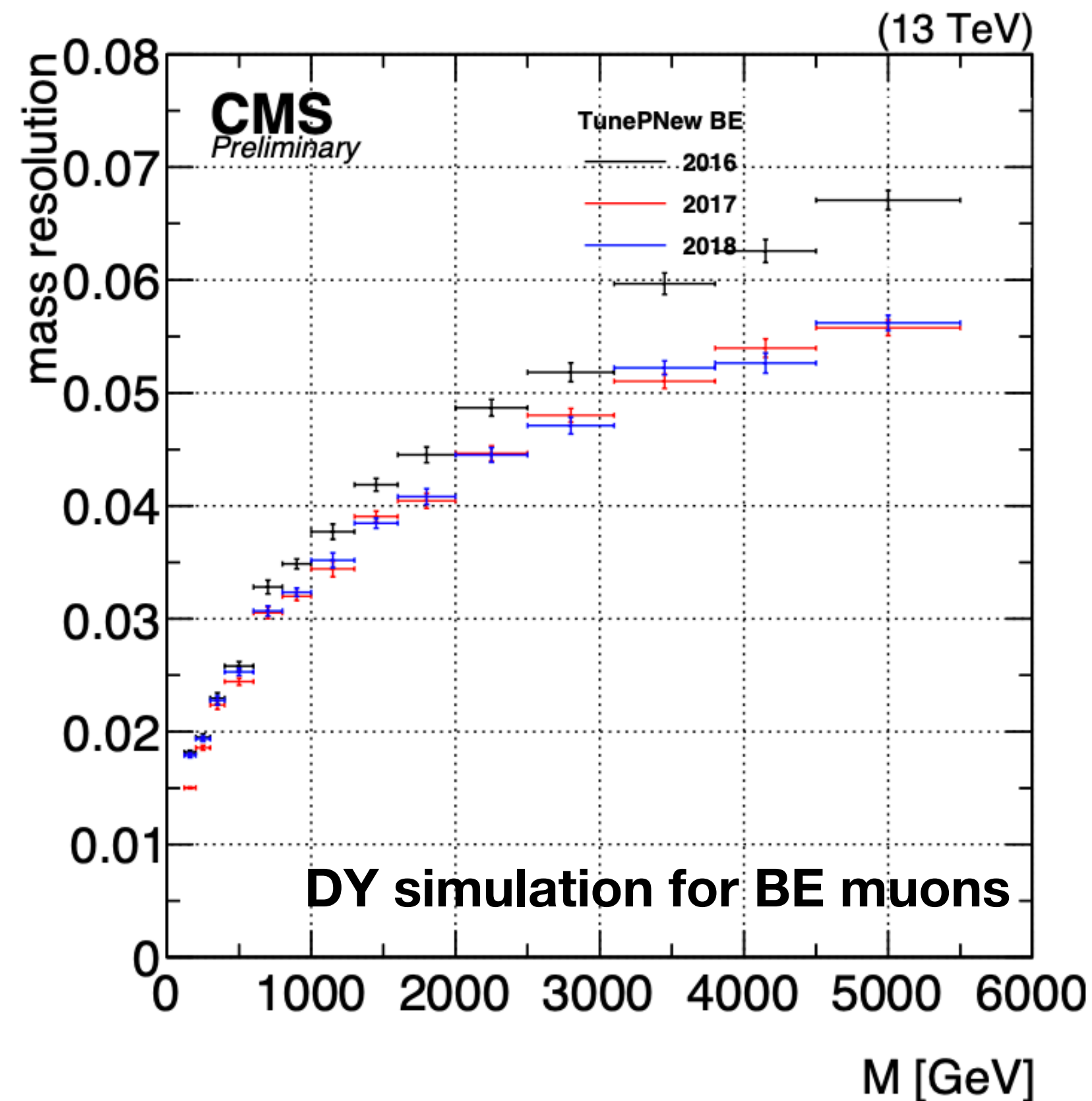
Unclear on which variable the extra smearing is applied (Mass?)
Unclear how to apply the systematics: Fix number at data card, additional smearing, if so on which variable?

Resolution smearing

The Zprime analysis uses a mass resolution to parametrize the signal: the extra smearing is then the additional sigma to be applied to the parametrization in order to get the resolution measured in data

$$\sigma_{\mu^+\mu^-}(m) = A + B \cdot m + C \cdot m^2 + D \cdot m^3 + E \cdot m^4$$

Boosted Z resolution in 2017 data and MC



$$\begin{aligned}\sigma_{extra} &= \sqrt{(\sigma_{data}^2 - \sigma_{MC}^2)} \\ &= \sqrt{(1.15^2 - 1)} = 0.57\end{aligned}$$

Resolution smearing

Dimuon prescription for 2017 : BE+EE extra smearing of 15% should be understood as « **multiply with 0.57 the mass resolution parametrization in MC, look at the new mass distribution obtained and use this distribution as nominal one in MC.** » The dimuon mass resolution parametrization should be given in the twiki.

Analysis not using the dimuon mass as final observable should look at single muon pT resolution and propagate the smearing to their final observable.

What should be the prescription for muon pT resolution?

We can not measure the single muon resolution in data in endcaps (for barrel we have cosmic muons). Two options (none of them fully correct):

- We can consider the extra smearing measured on the mass to be applicable on the muon pT (at first approximation it is correct). Then we need to provide the muon pT resolution as a function of pT in the twiki and then follow the procedure describe above
- We know that most of the worsening in data is coming from the tracker misalignment bias so we could apply Rochester to muons above 200 GeV and use the new distribution as nominal one
- We could check that both approach give equivalent result

Systematics

« **Systematic uncertainties on the resolution dominated by binning variations: 10%** »

First how the 10% are estimated? Obtained when estimating the resolution parametrization (changing mass window and binning of the distribution) in both plots shown on slide 5.

The 10% systematics should be applied as an extra sigma smearing on the mass resolution where σ_{Nom} is the nominal mass resolution of the MC (can contained the extra smearing of previous slide) :

$$\sigma_{sys} = \sqrt{\sigma_{Nom+10}^2 - \sigma_{Nom}^2} = \sqrt{1.1^2 - 1} = 0.46$$

«**Multiply by 0.46 the dimuon mass resolution parametrization from MC, sift the mass distribution in data based on this new parametrization and assign as systematic the difference measured on the final results between the two** »

We can follow the same procedure for single muon and get a systematic on the muon pT resolution parametrization

Proposal

We are updating the twiki (as part of the new recommendations) and should add:

- the dimuon mass resolution parametrization
- The extra smearing to get new MC nominal parametrization
- The systematic shift to be applied in data in order to compute the systematic on final observables
- Clarify how the smearing and shift needs to be propagated
- Add muon pT recommendation for analysis not working with dimuon quantity

Need to provide muon pT resolution parametrization for 2016, 2017 and 2018, barrel and endcaps

Could have the dimuon and single muon resolution parametrization in Spark (as part of the new branch for scale and resolution)

Need to cross check if a single muon pT resolution smearing is equivalent to apply Rochester for run 2.