Jet-Veto Efficiency for WW

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Previous talk: http://indico.cern.ch/contributionDisplay.py?contribId=0&confId=107755

Outline

- The jet-veto signal efficiency and systematics
- The jet-veto efficiency in Z data
- The WW/Z jet-veto efficiency ratio
- WW jet-veto efficiency
- Summary and Conclusion

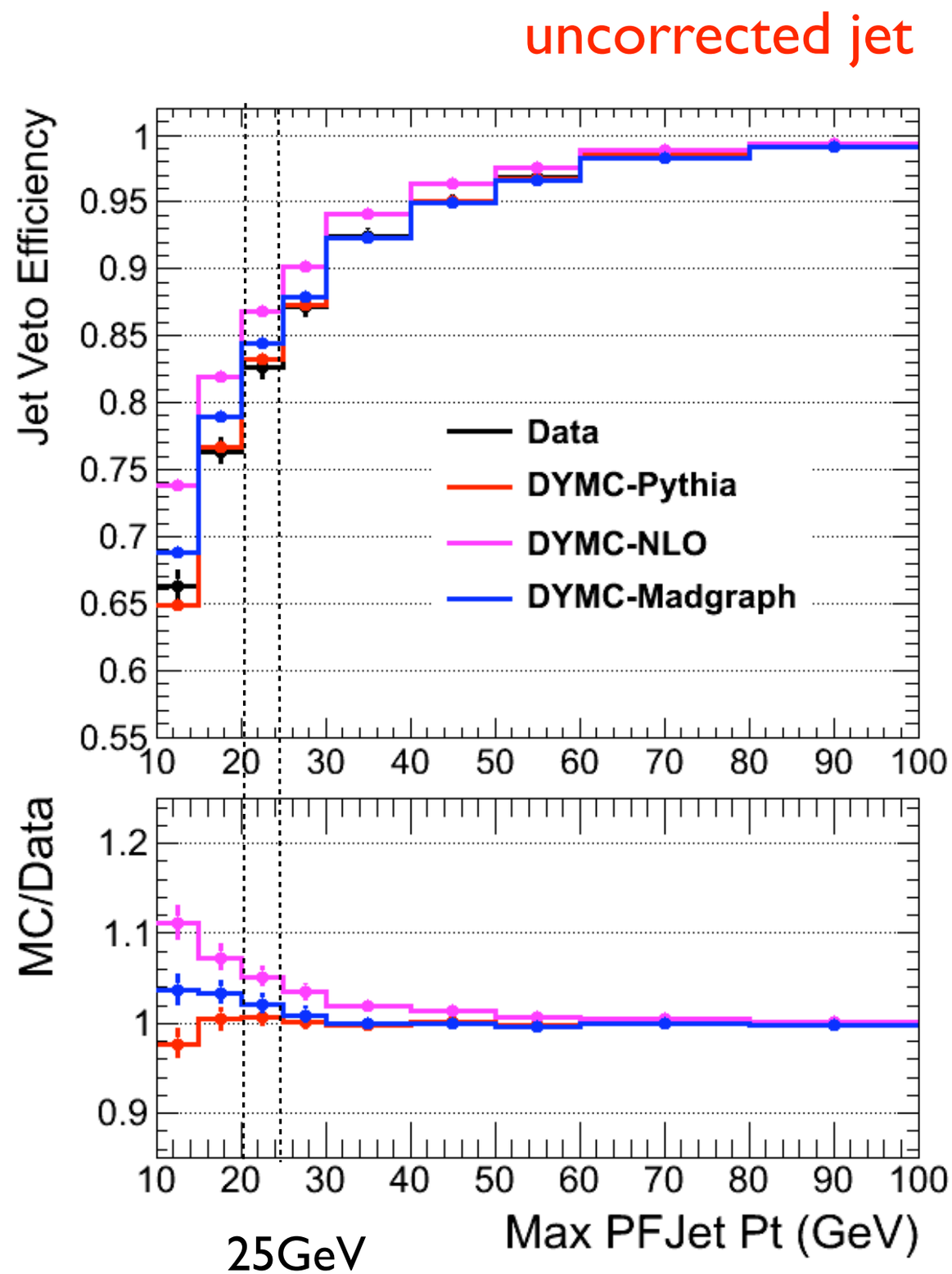
Corrections from the last talk

- The MC@NLO numbers in the last talk didn't account for the negative weights properly, this is fixed in today's talk. Nevertheless, the jet energy spectrum in MC@NLO sample is still softer than the data for the Z events
- The reported efficiency numbers in the last talk were taken by mistake from a wrong bin
- All the above corrections do not change the basic conclusions

Jet-veto Efficiency in Z Data

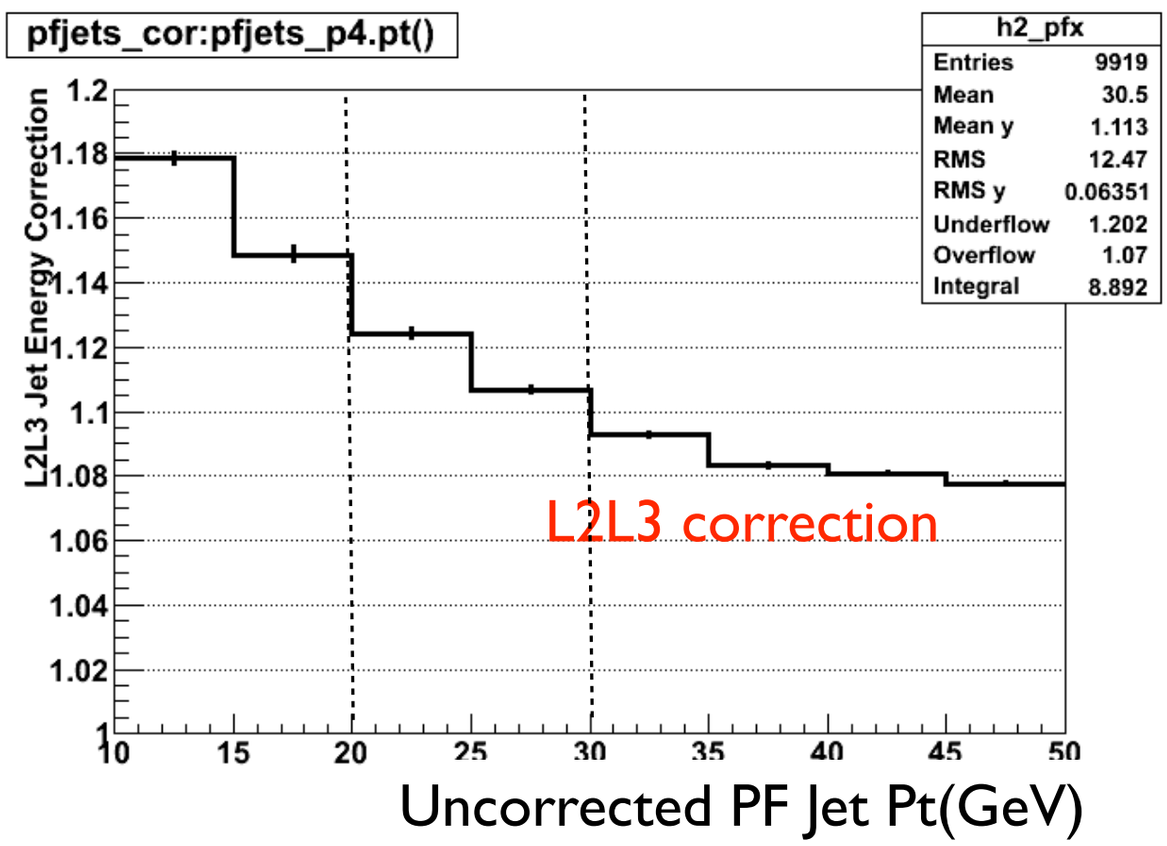
Jet-veto Efficiency Measurement in Z

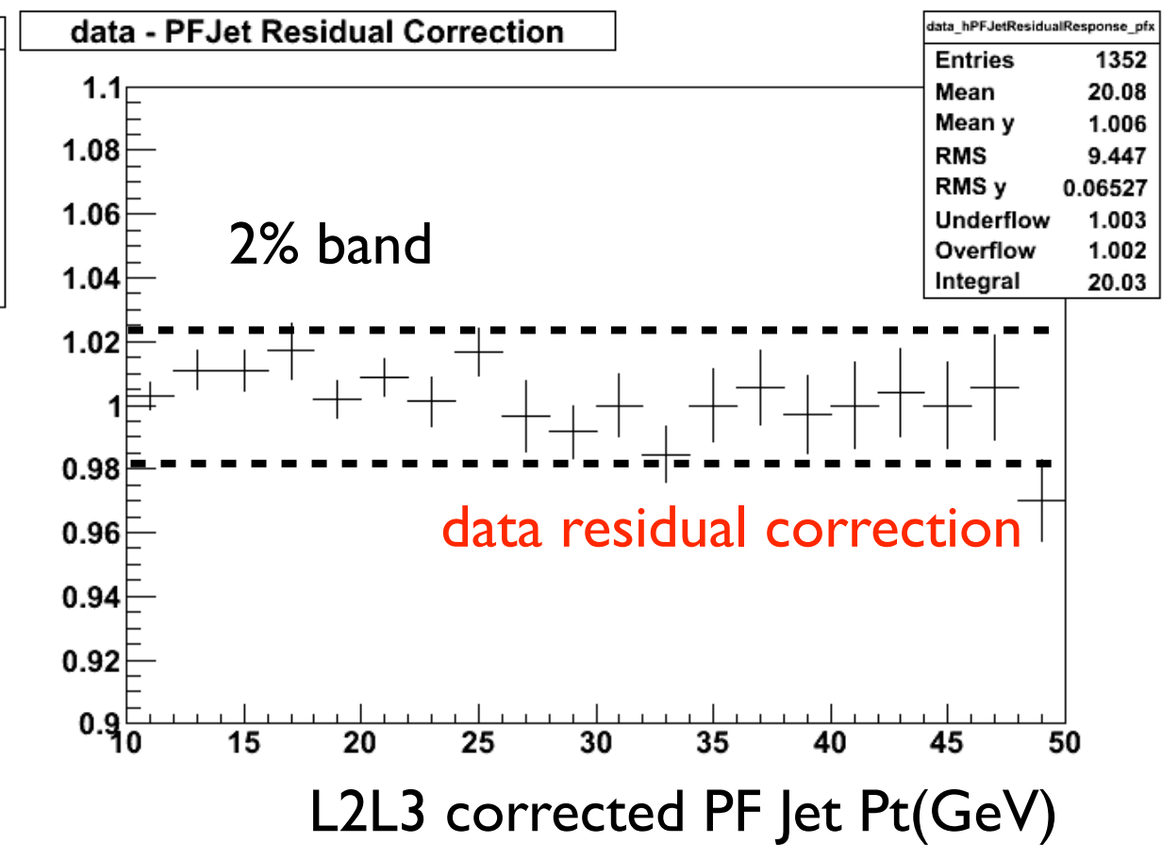
- What we have learned
  - The MC/data ratio of jet-veto efficiency using jets at HF region (3<|η|<5) is ~ 1, we apply the jet veto region to |η|<5 range
  - The jet energy spectrum in the MC@NLO is softer than data
  - The jet-veto efficiency in pythia and madgraph agree with data well
  - We get similar results using JPT/Calo/TrkJet



L2L3 Jet Energy Corrections for PFJet

- JEC recipe: https://hypernews.cern.ch/HyperNews/CMS/get/JetMET/1017.html (Konstantinos Kousouris)
  - For data and MC, apply L2 and L3 corrections
  - For data, apply the additional residual corrections





~11% for jet (20-30)GeV

Jet-veto Efficiency on Z

- Jet-veto efficiency on Z with uncorrected PFJet

Jet-veto Cut (GeV)	Pythia/Data (%)	Madgraph/Data (%)	MC@NLO/Data (%)	$\epsilon_Z^{data}(\%)$
20	100.4± 1.3	103.4± 1.4	107.3± 1.4	76.3± 1.0
25	100.7± 1.1	102.1± 1.1	105.1± 1.2	82.6± 0.9
30	100.2± 0.9	100.9± 0.9	103.5± 1.0	87.2± 0.8

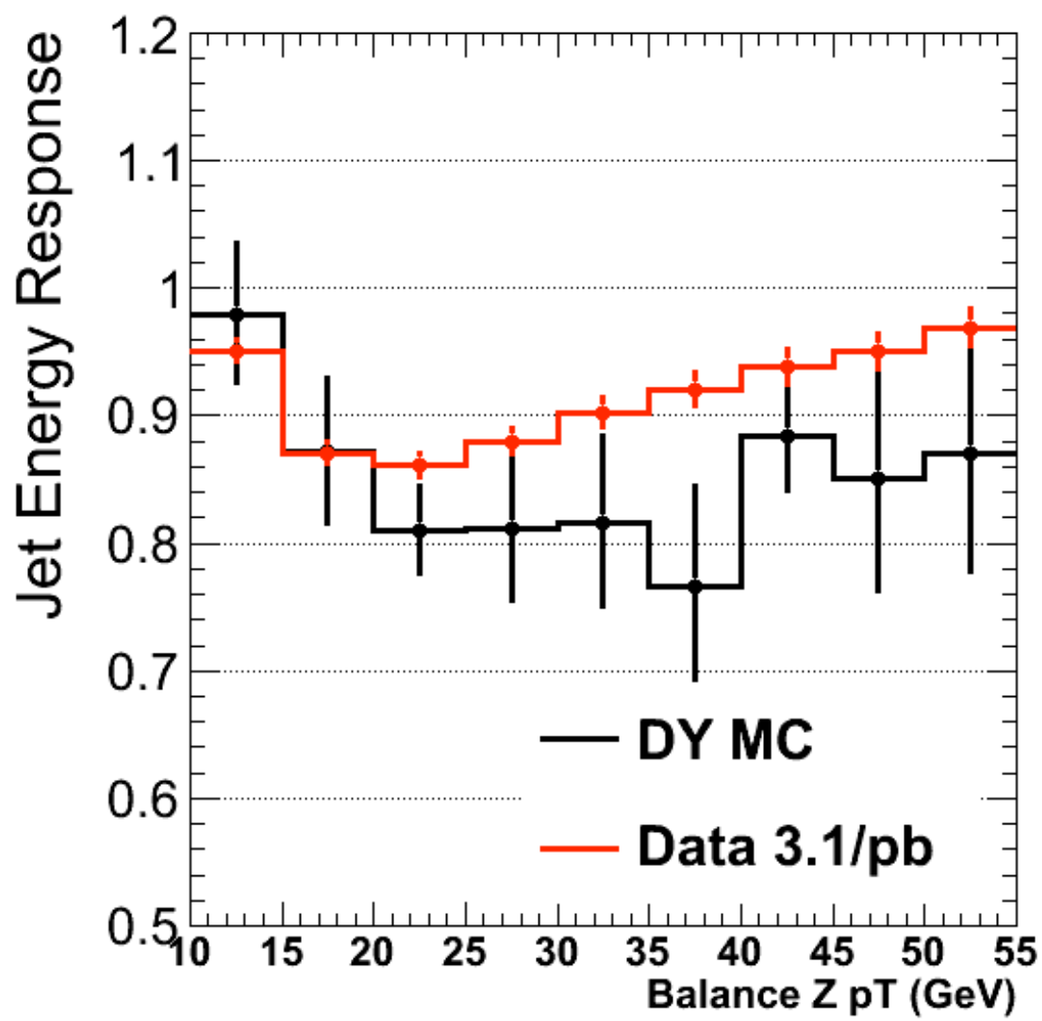
- Jet-veto efficiency on Z with L2L3+residual corrected PFJet

Jet-veto Cut (GeV)	Pythia/Data (%)	Madgraph/Data (%)	MC@NLO/Data (%)	$\epsilon_Z^{data}(\%)$
20	100.3± 1.5	104.8± 1.6	109.6± 1.7	71.3± 1.1
25	101.4± 1.3	103.7± 1.3	106.8± 1.3	78.8± 1.0
30	100.5± 1.0	101.8± 1.0	104.4± 1.1	84.5± 0.9

  - With ~11% correction at (20-30GeV), efficiency drops ~ 4%
  - But the MC/data ratio using corrected jet stays consistent with the ratio using uncorrected jets (within statistical errors)

Jet Energy Correction Using Z Balance

- The standard L2L3 JEC is derived for high pT jets, we need to cross-check the corrections in the region (20-30) GeV
- For this validation, we use Z+1 Jet events, with the selections,
  - |ΔΦ(leading jet-diLepton)-π|<0.2
  - Other jets in the event with pT < 0.1 * leading jet pT
- The jet response is defined as corrected leading jet pT / dilepton pT



1. There is an overall systematic difference in data vs MC, however data is statistically limited

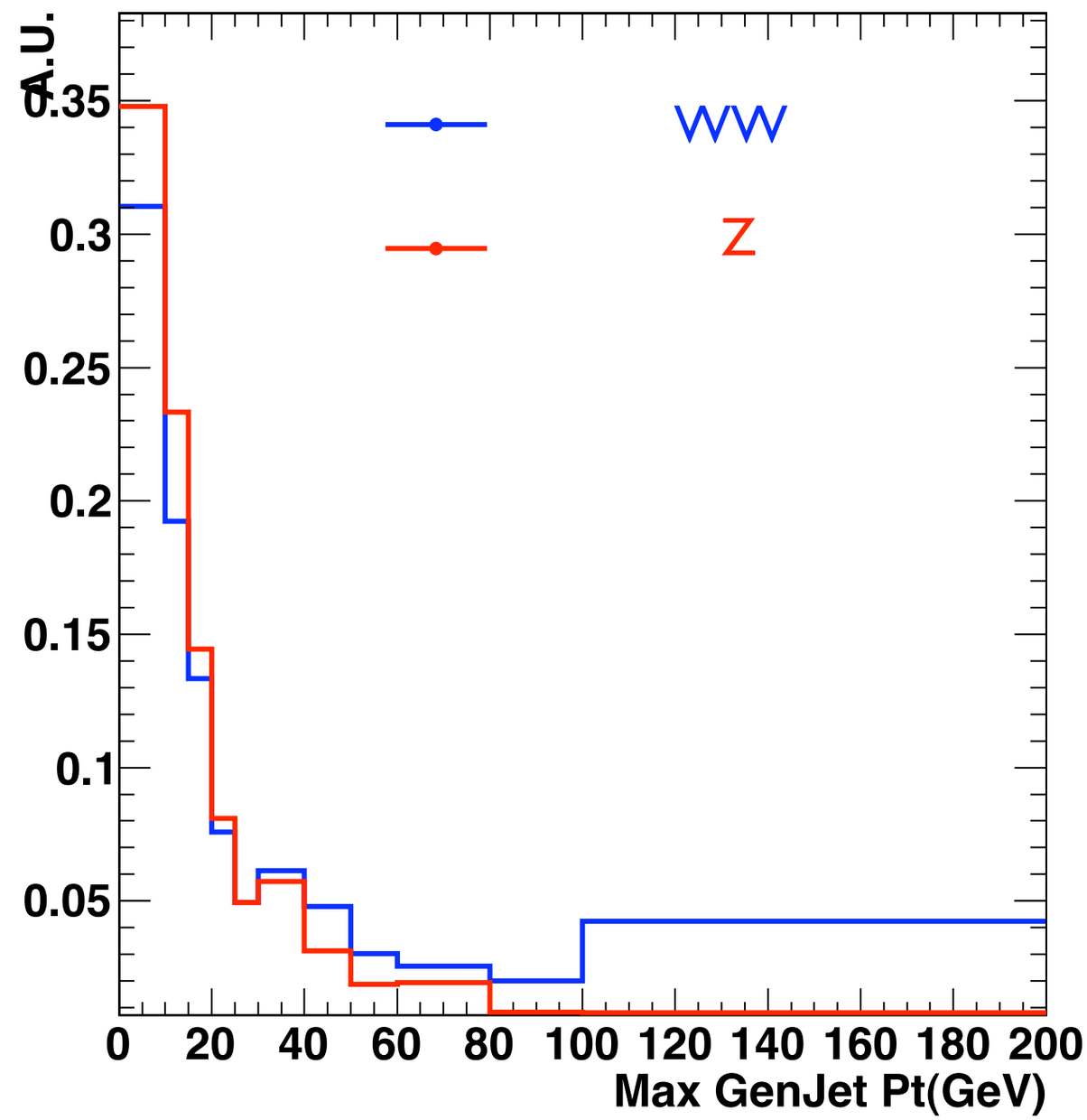
2. Similar conclusion is found from γJets study, Francesco Pandolfi http://indico.cern.ch/getFile.py/access?contribId=0&resId=0&materialId=slides&confId=108390

3. Assume the 7% at 25GeV is real, we get ~2-3% additional uncertainty from JEC, this needs to be checked with more data

WW/Z Jet-veto Efficiency Ratio

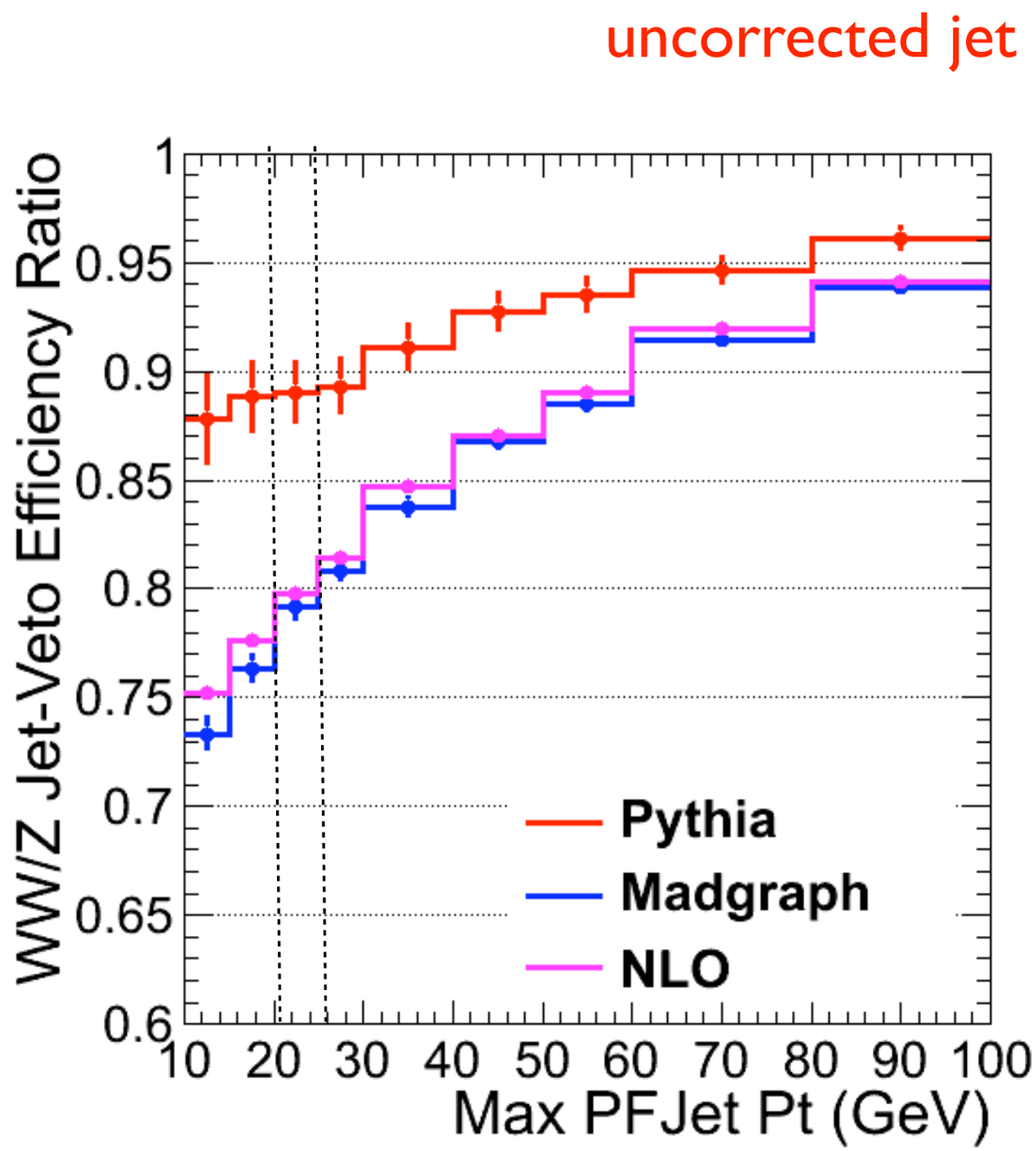
WW/Z Jet Energy Spectrum

- The kinematics in WW is different from Z due to the higher scattering energy scale
- The jet energy spectrum from WW is harder than Z
- The extrapolation of the jet-veto efficiency from ~90GeV t ~180GeV is sensitive to the higher order corrections



WW/Z Jet-veto Efficiency Ratio

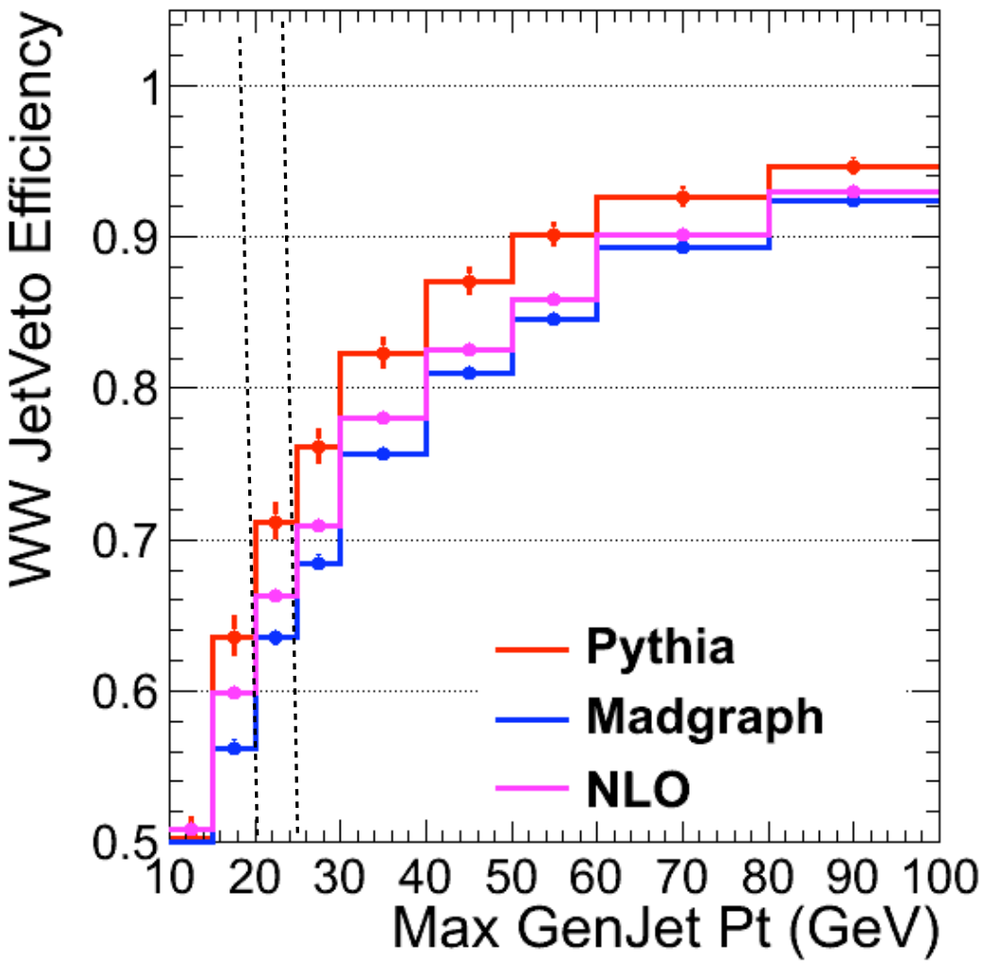
- As three MC samples agree with each other at control region Z, the difference mainly comes from WW (next slide)
  - For WW, Pythia treats the corrections beyond LO in the parton showering
  - For WW, Madgraph/ MC@NLO include up to WW+1parton in ME calculation

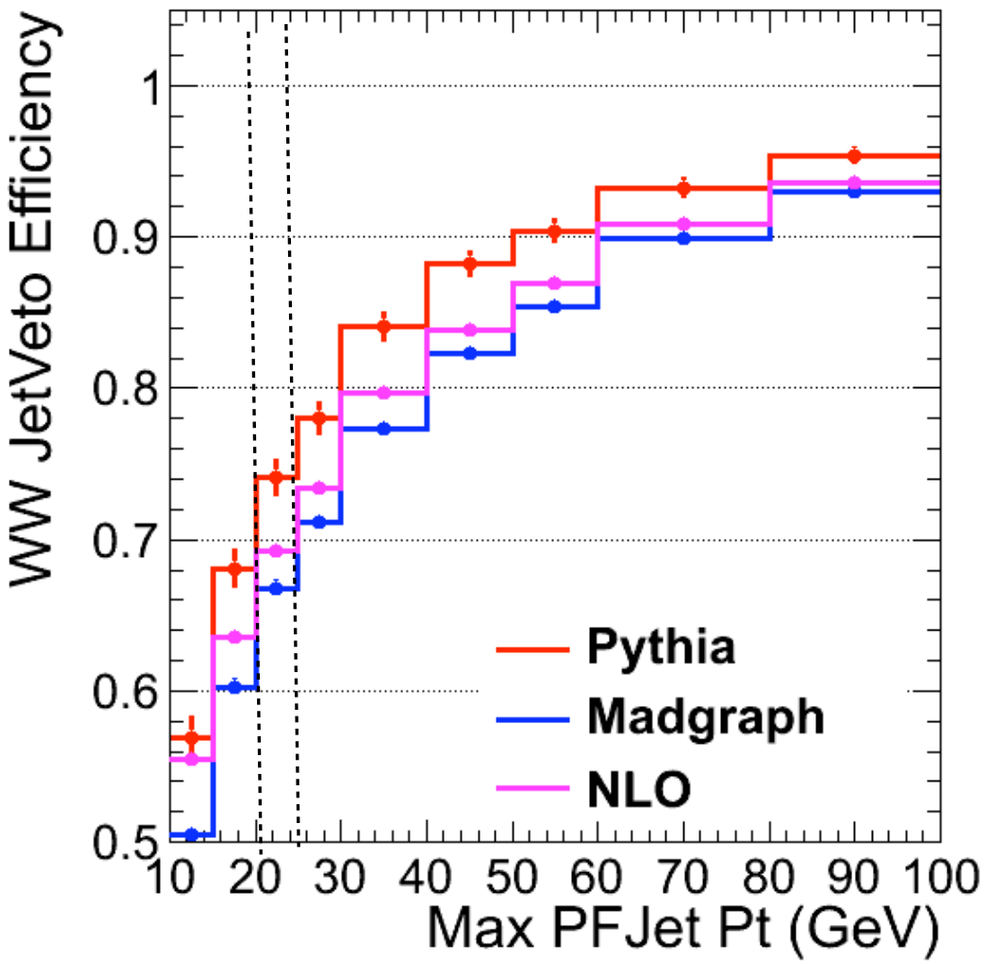


WW Efficiency in MC

- WW jet-veto efficiency from the MC

uncorrected jet





- Our proposal for the WW/Z Ratio:
  - Take the madgraph as the nominal MC to calculate the ratio
  - Assign half of the pythia and madgraph difference as systematic error

WW Jet-veto Efficiency Estimate for Data

- Jet-veto efficiency using uncorrected PFJet

Jet-veto Cut (GeV)	ϵ_Z^{data} (%)	$R_{WW/Z}^{MC}$ (%)	ϵ_{WW} (%)
20	76.3 ± 1.0	$76.3 \pm 0.7 \pm 6.2$	$58.3 \pm 0.9 \pm 4.8$
25	82.6 ± 0.9	$79.1 \pm 0.6 \pm 4.9$	$65.4 \pm 0.9 \pm 4.1$
30	87.2 ± 0.8	$80.9 \pm 0.6 \pm 4.2$	$70.5 \pm 0.8 \pm 3.7$

- Jet-veto efficiency using corrected PFJet

x: -370 px y: -26 px

Jet-veto Cut (GeV)	ϵ_Z^{data} (%)	$R_{WW/Z}^{MC}$ (%)	ϵ_{WW} (%)
20	71.3 ± 1.1	$74.9 \pm 0.7 \pm 6.5$	$53.4 \pm 1.0 \pm 4.6$
25	78.8 ± 1.0	$77.5 \pm 0.7 \pm 5.7$	$61.1 \pm 0.9 \pm 4.5$
30	84.5 ± 0.9	$79.7 \pm 0.6 \pm 4.8$	$67.3 \pm 0.9 \pm 4.1$

- Relative uncertainty ~ 8% for 25GeV (working point), dominated by the WW/Z ratio uncertainty
- These numbers are not final, need to add additional uncertainty from the JEC (need to confirm with more data)

Summary and Conclusion

- We have a data-driven procedure to estimate the WW jet-veto efficiency and its systematic uncertainty in data $\epsilon_{WW}^{data} \approx \epsilon_{Z}^{data} \times (\epsilon_{WW}^{MC}/\epsilon_{Z}^{MC})$
- We measured the Z jet-veto efficiency in data.
  - The data measurement agree with the MC predictions
- We studied the WW/Z jet-veto efficiency in MC
  - We take the Madgraph for the nominal efficiency
  - The Pythia-Madgraph difference is taken as the uncertainty, this is the dominant systematic error in WW efficiency uncertainty
- We cross checked the JEC using Z+1 jet balance method
- WW Jet-veto efficiency:
  - 61.1±0.9±4.5(%) using corrected PFJet @ jet pT < 25 GeV
  - The number is not final, we will update using 38MC and more data

WW jet-veto efficiency

Jet-veto Signal Efficiency

- One way to estimate jet-veto signal efficiency

$$\epsilon_{WW}^{data} = \epsilon_{Z}^{data} \times \frac{\epsilon_{WW}^{data}}{\epsilon_{Z}^{data}} \dashrightarrow R_{WW/Z}^{data}$$

$$\epsilon_{WW}^{data} = \epsilon_{Z}^{data} \times R_{WW/Z}^{MC}$$

  - Main question in estimating the systematic error on jet-veto signal efficiency is how well does the MC reproduces data in this ratio?
    - First we look at the Z data to see the data/MC matching
    - Select the MCs with good data/MC matching in the control region (Z), and assign half of the biggest difference in $R_{WW/Z}$ as the systematic error on $R_{WW/Z}$
      - Pitfall: what if both MCs are wrong in predicting the $R_{WW/Z}$? However we don't have a good reason for this to happen

- Propagate the errors on ϵ_{Z}^{data} and $R_{WW/Z}$ for the systematic error on WW jet veto signal efficiency

Z Selections

- Z selection differences from WW reference
  - |M(ll)- 91.1876| <15 GeV in EE/MM
  - If multiple hypo. are found, choose the one with m(ll) closest to Z mass
  - Relax all jet-veto and MET cuts
  - Relax all trigger selections
  - Relax soft muon and third lepton vetos
- Number of Events after the Z selection: 629 (EE) 1109 (MM)