b-jet production at the LHC using PBTMD

2020REF Workshop

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OUTLINE

$Z + b$ jet production at NLO

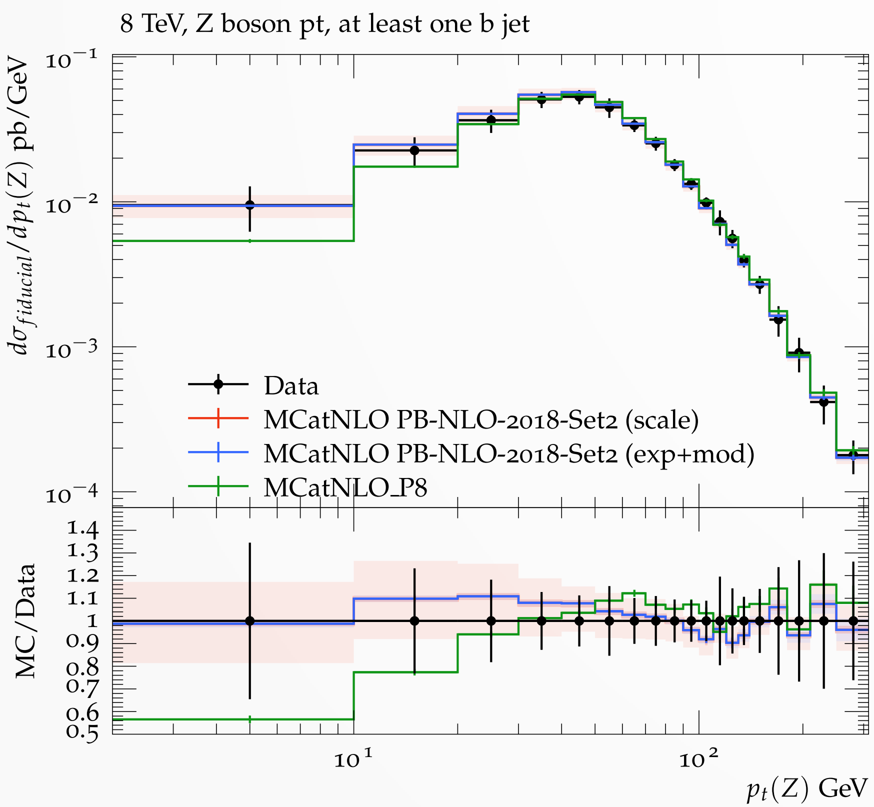
- Sensitivity to TMD
- Sensitivity to TMD initial state parton shower
- Z + b and bb correlations

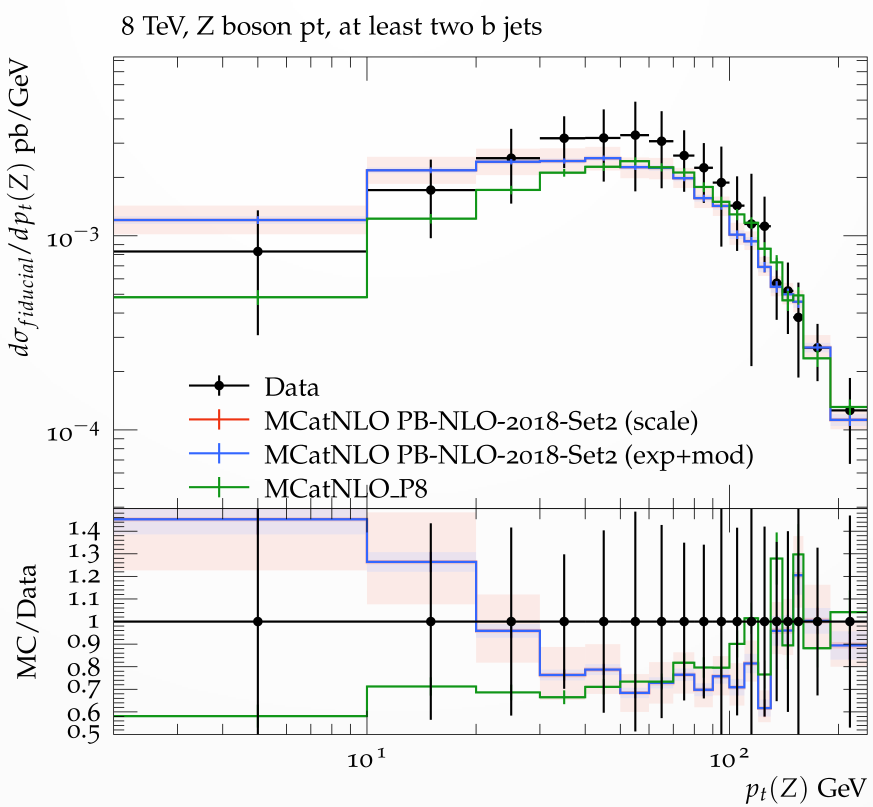
$Z + b$ jets at NLO

- MCatNLO for Z+b : (5-flavor (5FS) and 4-flavor scheme (5FS) PB TMD)
  - Using Herwig6 subtraction terms
  - PB-TMD to generate initial k_T
  - Initial state parton shower following PB-TMD (same α_s , same NLO splitting functions and cut-off params)

- Uncertainties:
  - NLO scale uncertainties
  - PDF (TMD) uncertainties

$Z + b$ jets at NLO (5FL)



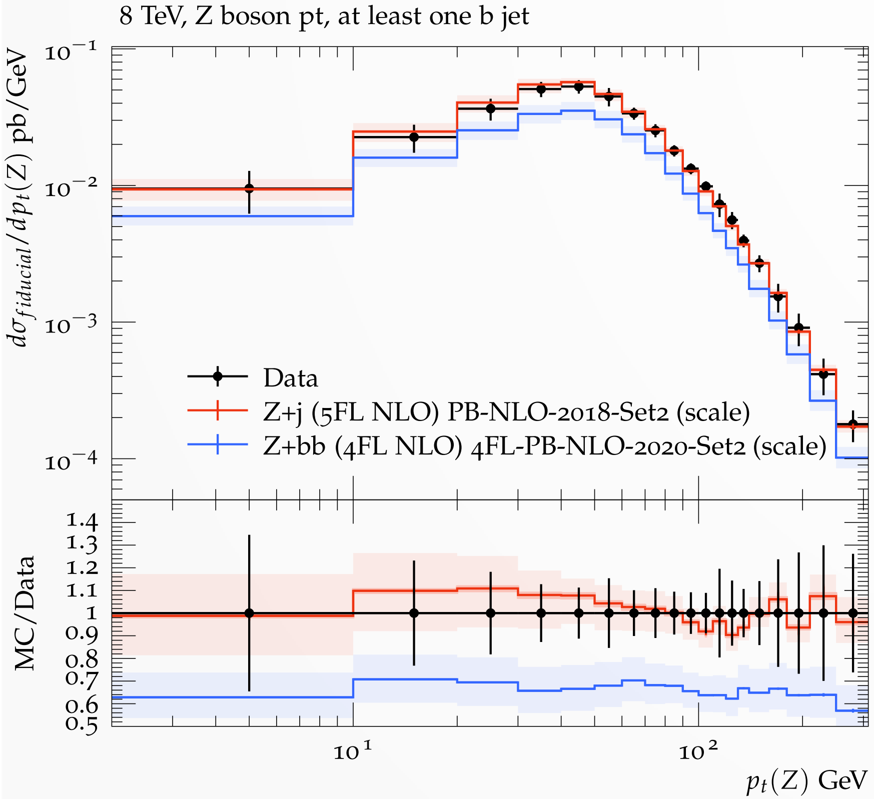


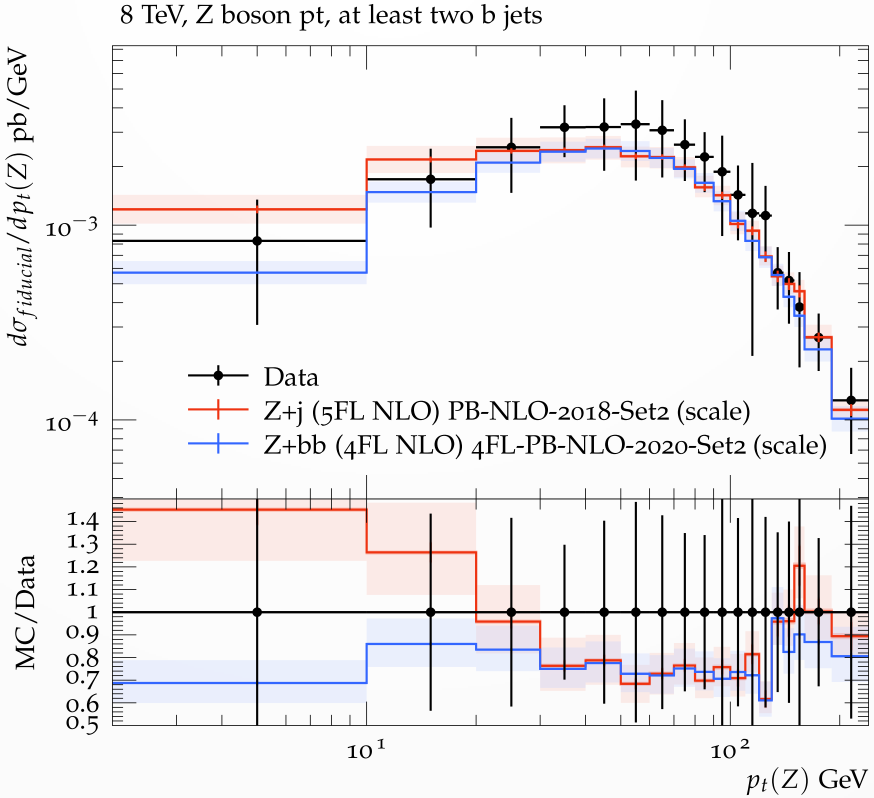
❖ **Phase space cuts:**

- ***Leptons :***
  - $|\eta| < 2.4$
  - $p_T > 20\ GeV$
  - $71\ GeV < m_{ll} < 111\ GeV$
- ***Jets :***
  - anti $-k_T$
  - $R = 0.5$
  - $|\eta| < 2.4$
  - b-Hadron $p_T > 30\ GeV$

- Comparison PB-TMD and P8 shower shows good agreement at high pt but a better description at low pt from PB-TMD (1 bjet case).
- Scale uncertainty dominates.

$Z + b$ jets at NLO (4FL)





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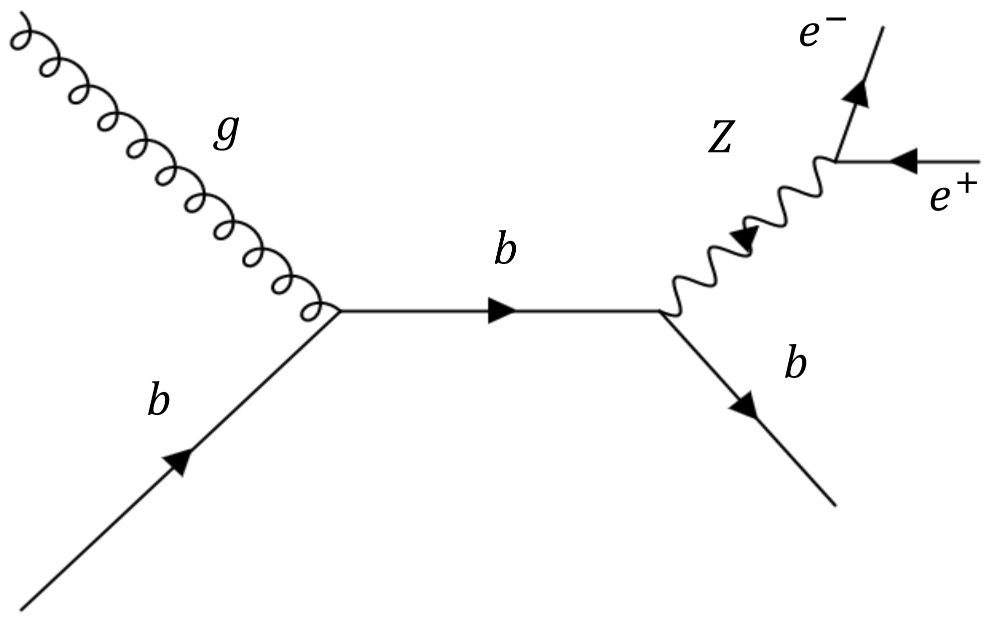
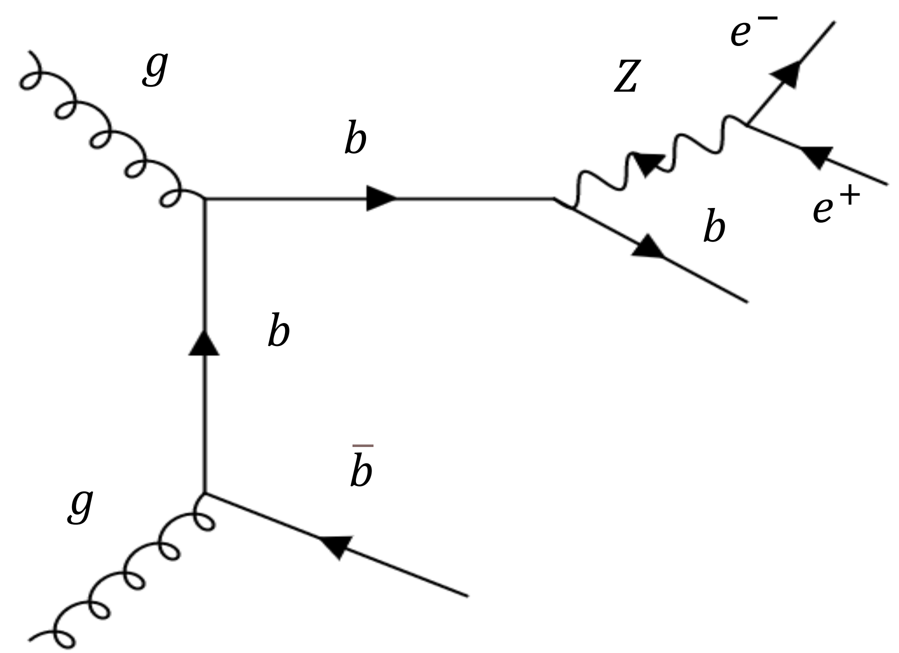
- Better description coming from 5FL in Z+b.
- In Z + bb case we have a similar description.

$Z + b$ jets (5FS): initial state k_T

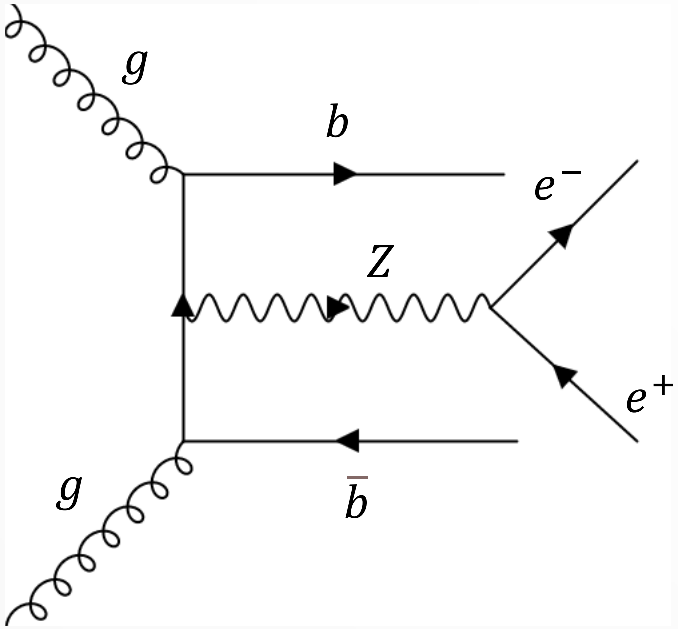


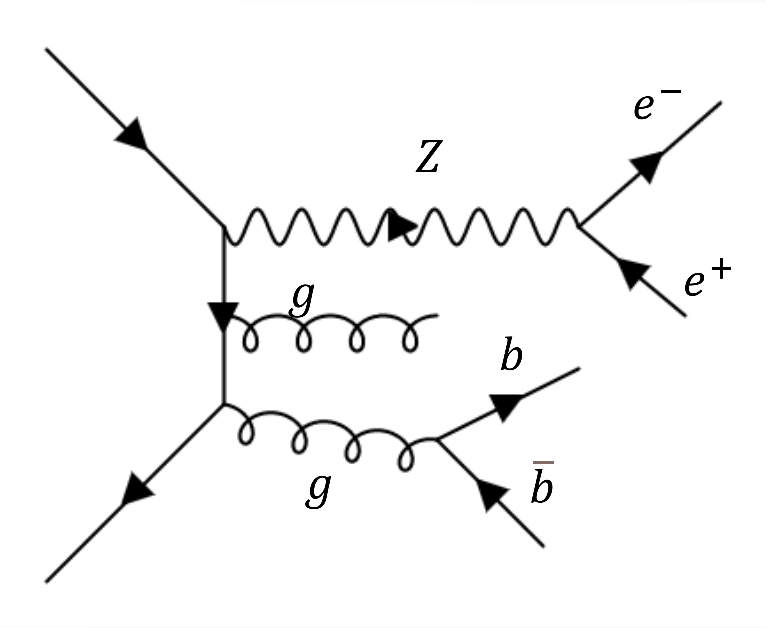


- In LO : $\Delta\phi(\mathrm{Z,b}) = \pi$
  - TMD introduces k_T on g and b creating the decorrelation

- In NLO : $\Delta\phi(\mathrm{Z,b}) \leq \pi$
  - TMD introduces k_T on g and additional decorrelation on $\Delta\phi(\mathrm{Z,b})$

$Z + b$ jets (4FS): initial state k_T

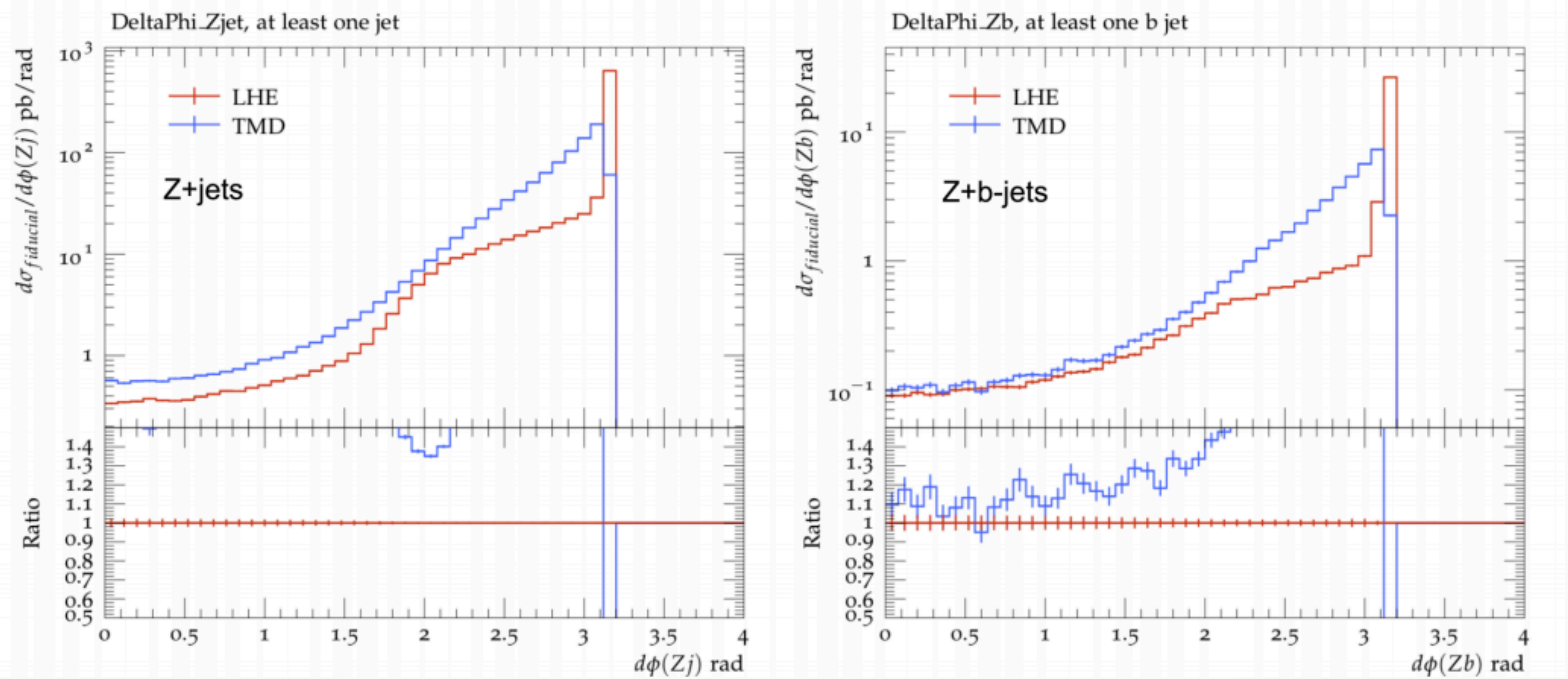




- In LO : $\Delta\phi(\mathrm{Z,b}) \leq \pi$
  - Decorrelation can appear already without k_T

- In NLO : $\Delta\phi(\mathrm{Z,b}) \leq \pi$
  - TMD introduces k_T on g and additional decorrelation on $\Delta\phi(\mathrm{Z,b})$

$Z + b$ jets: initial state k_T



- Comparig to Z+jets in Z+b jets **TMD** is clearly important at large $\Delta\phi$

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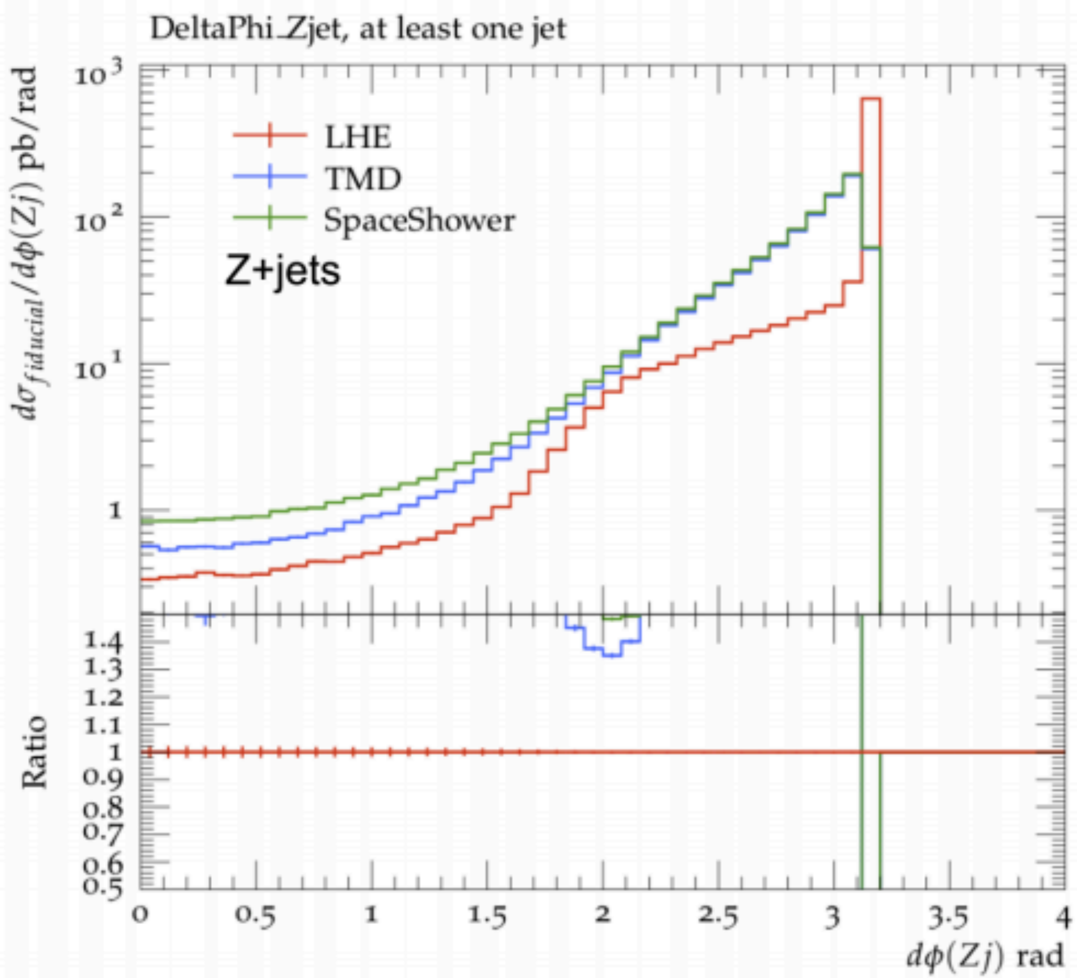
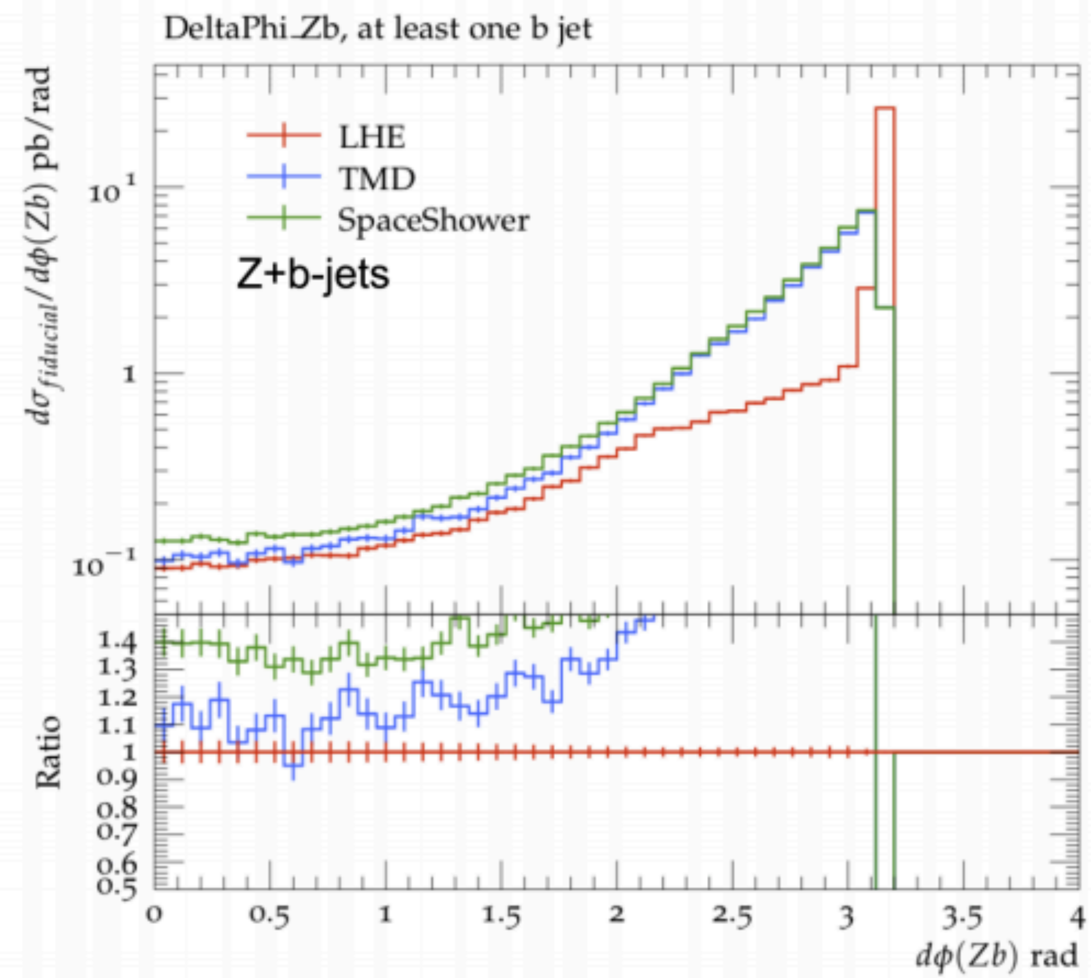
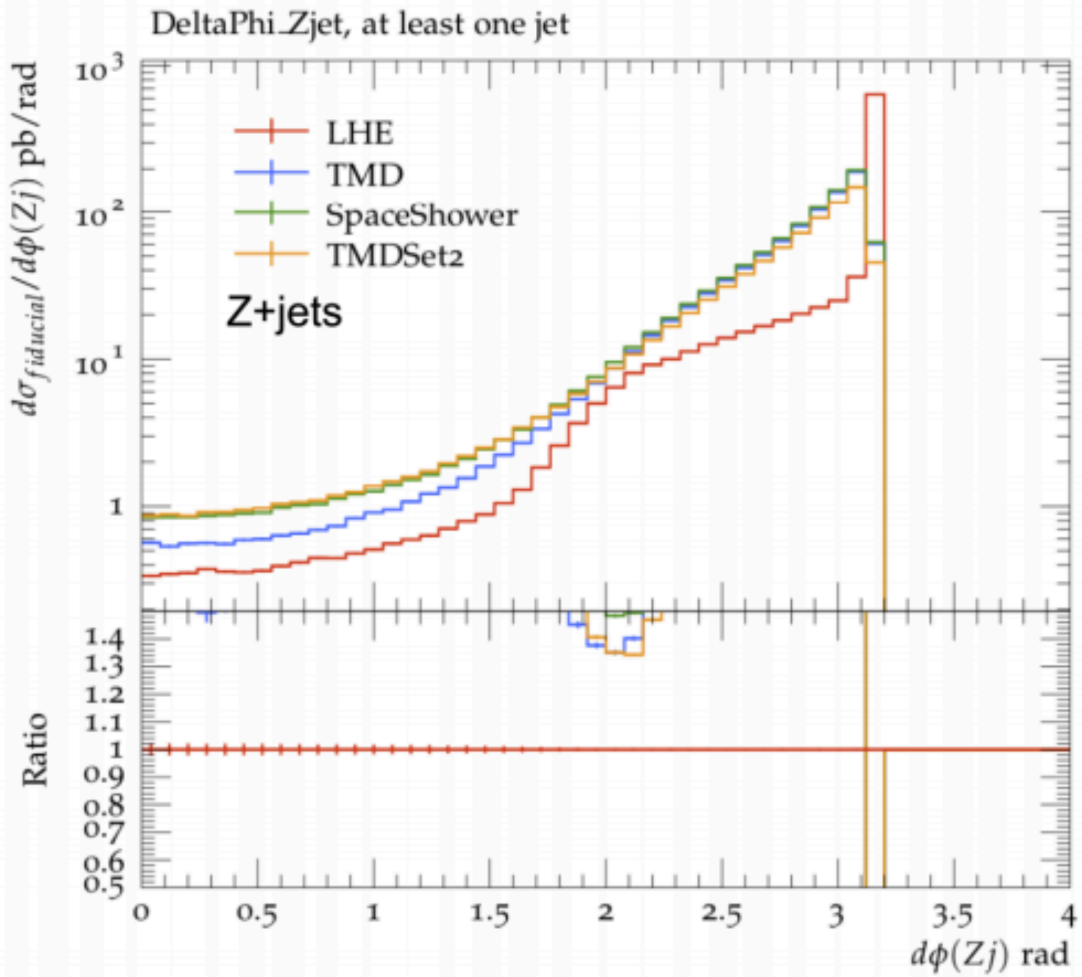
$Z + b$ jets: initial state k_T

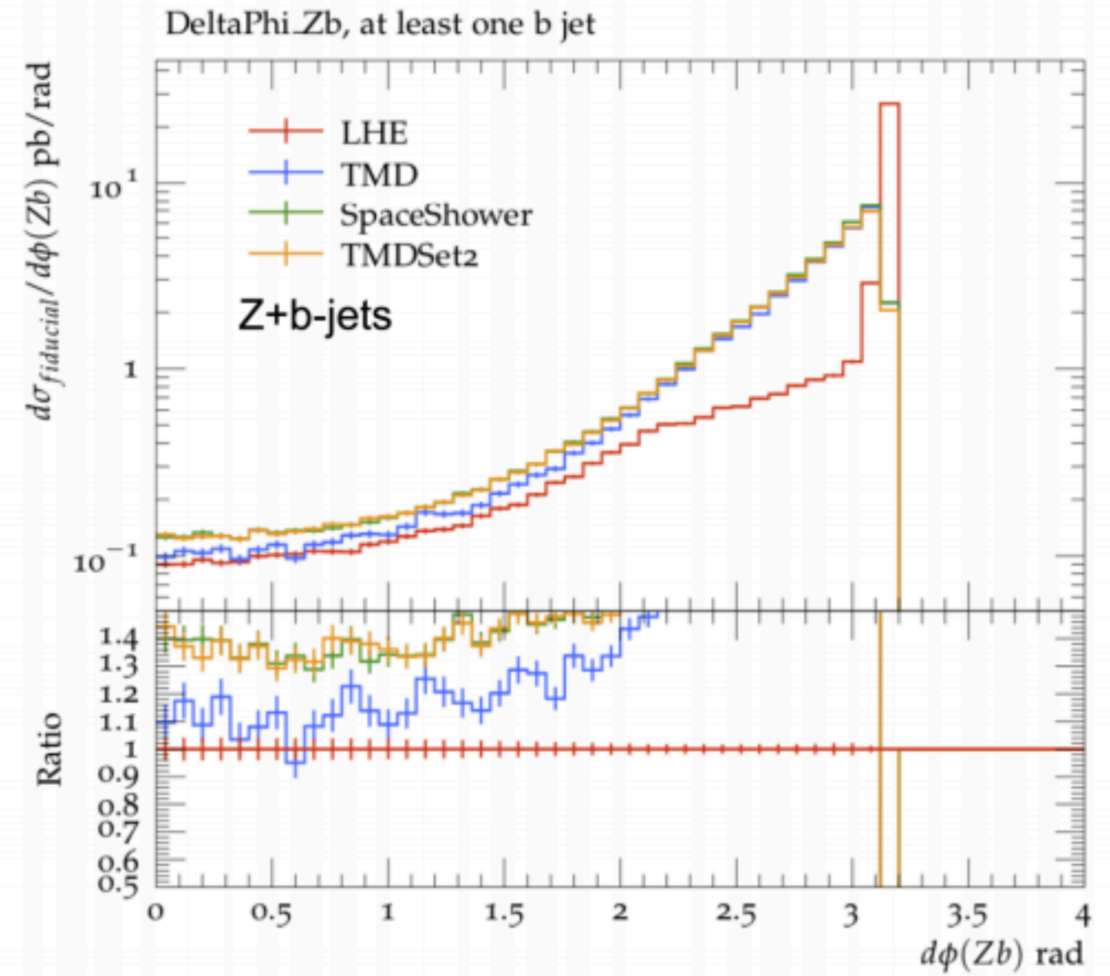




- Initial state PS (SpaceShower) only small effect at small $\Delta\phi$ (on top of **TMD**)

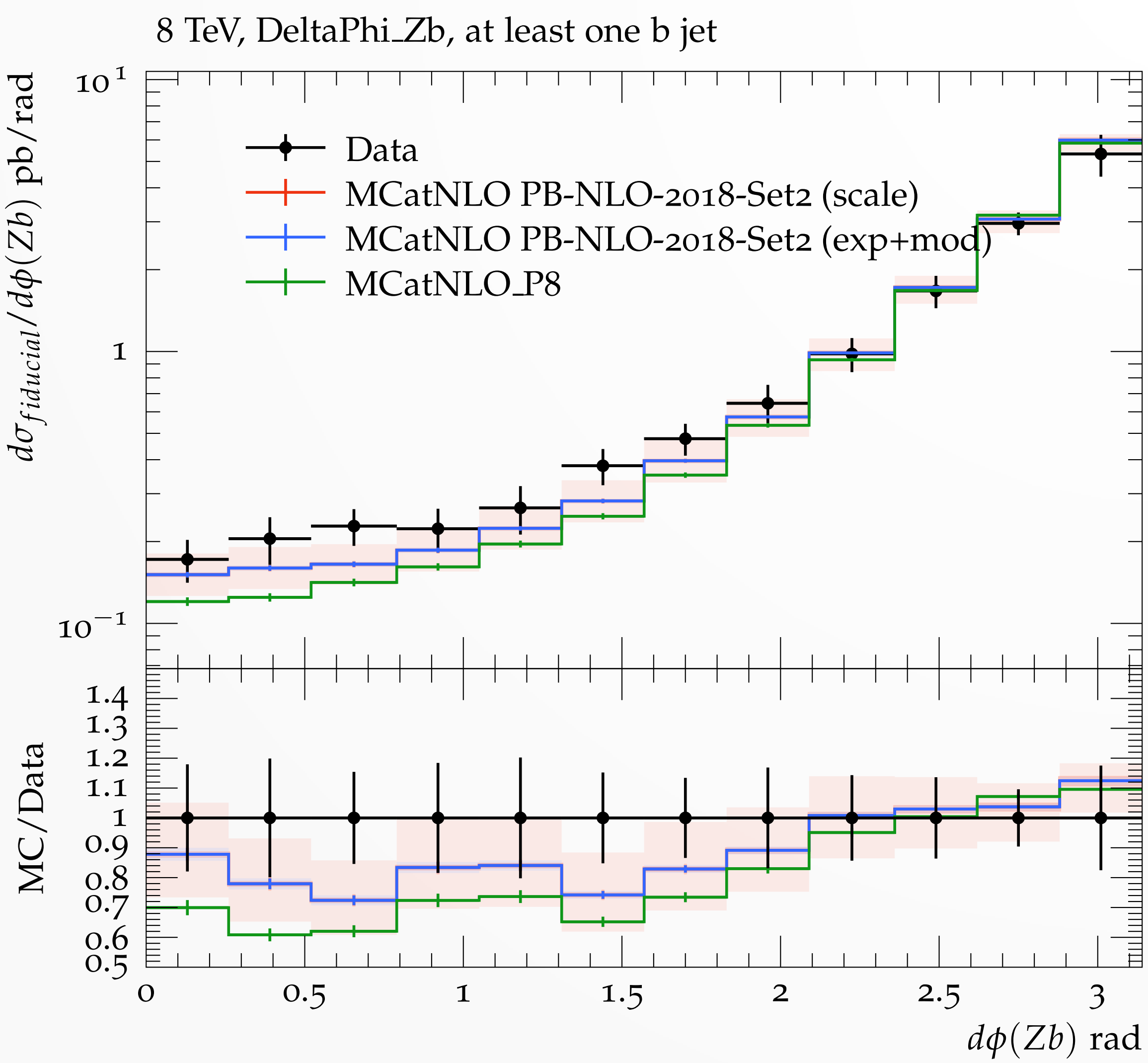
$Z + b$ jets: initial state k_T





- ISR + FSR (TMDSet2) only small effect on top of **TMD** and PS (**space shower**)

$\Delta\phi(Z,b)$ comparison to measurement



- Good description in the back-to-back region where TMD effects are relevant.
- Decorrelation comes essentially from the kT in the initial evolution.
- Initial and final showers are less important (see previous slides)
- Distribution essentially determined from PBTMD evolution.
- Scale uncertainty dominates

Z + b-jet correlation tests TMD

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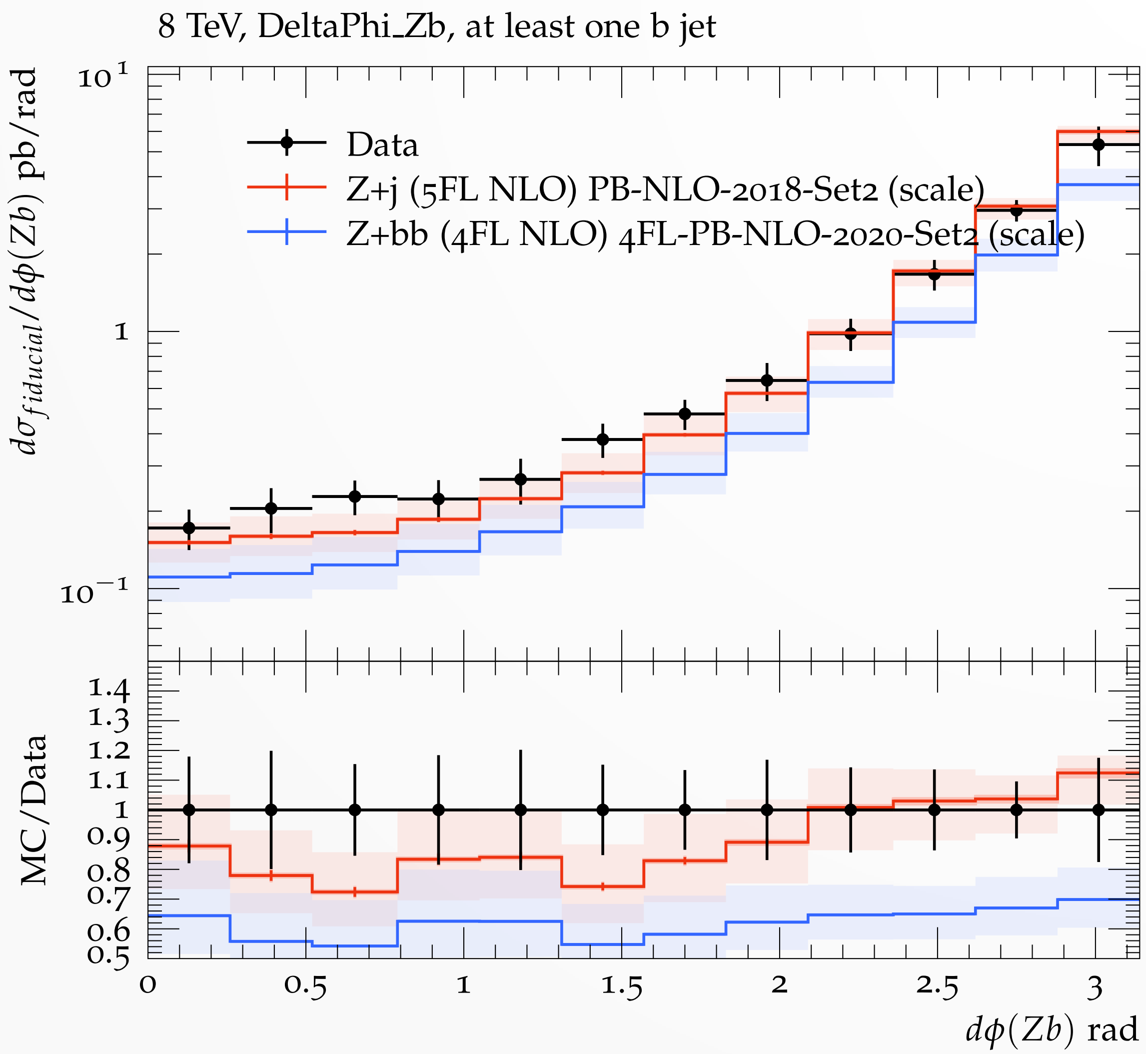
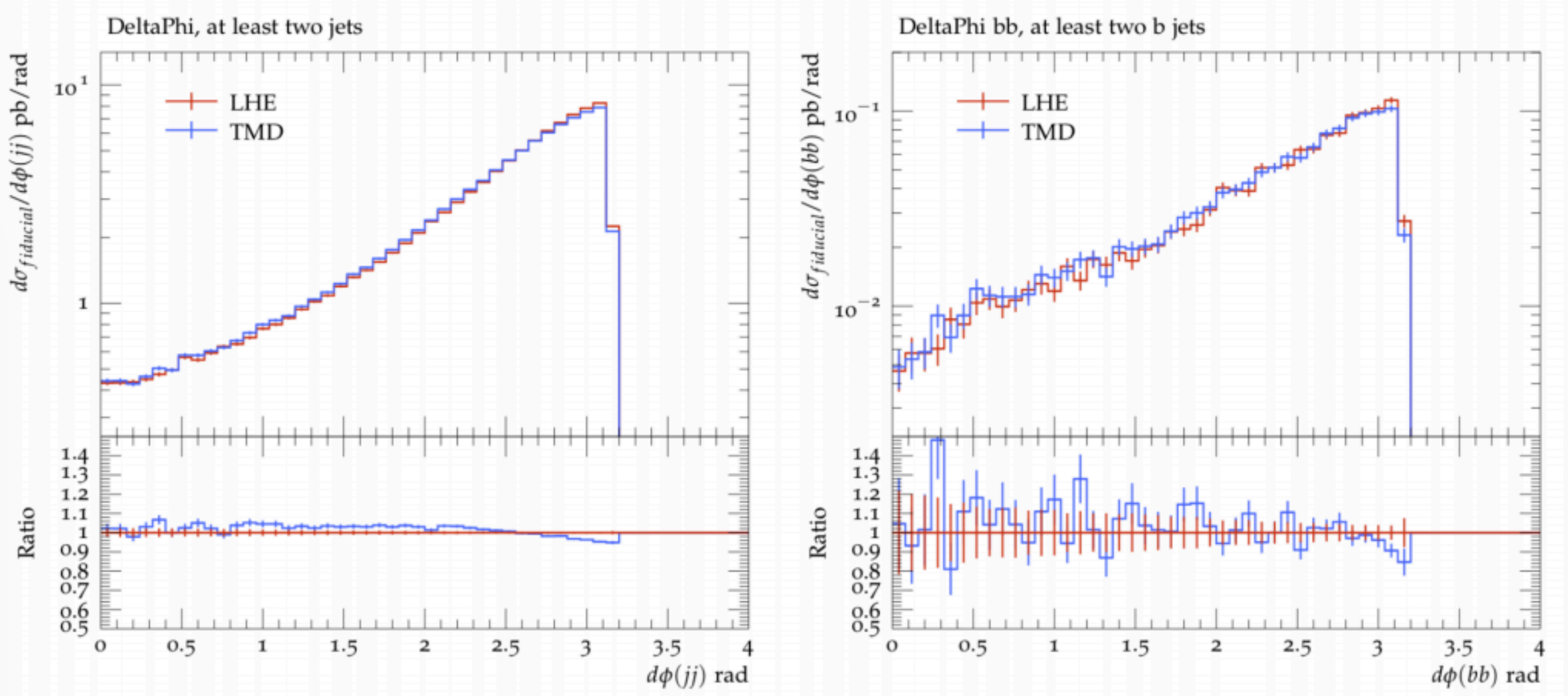
$\Delta\phi(Z,b)$ comparison to measurement



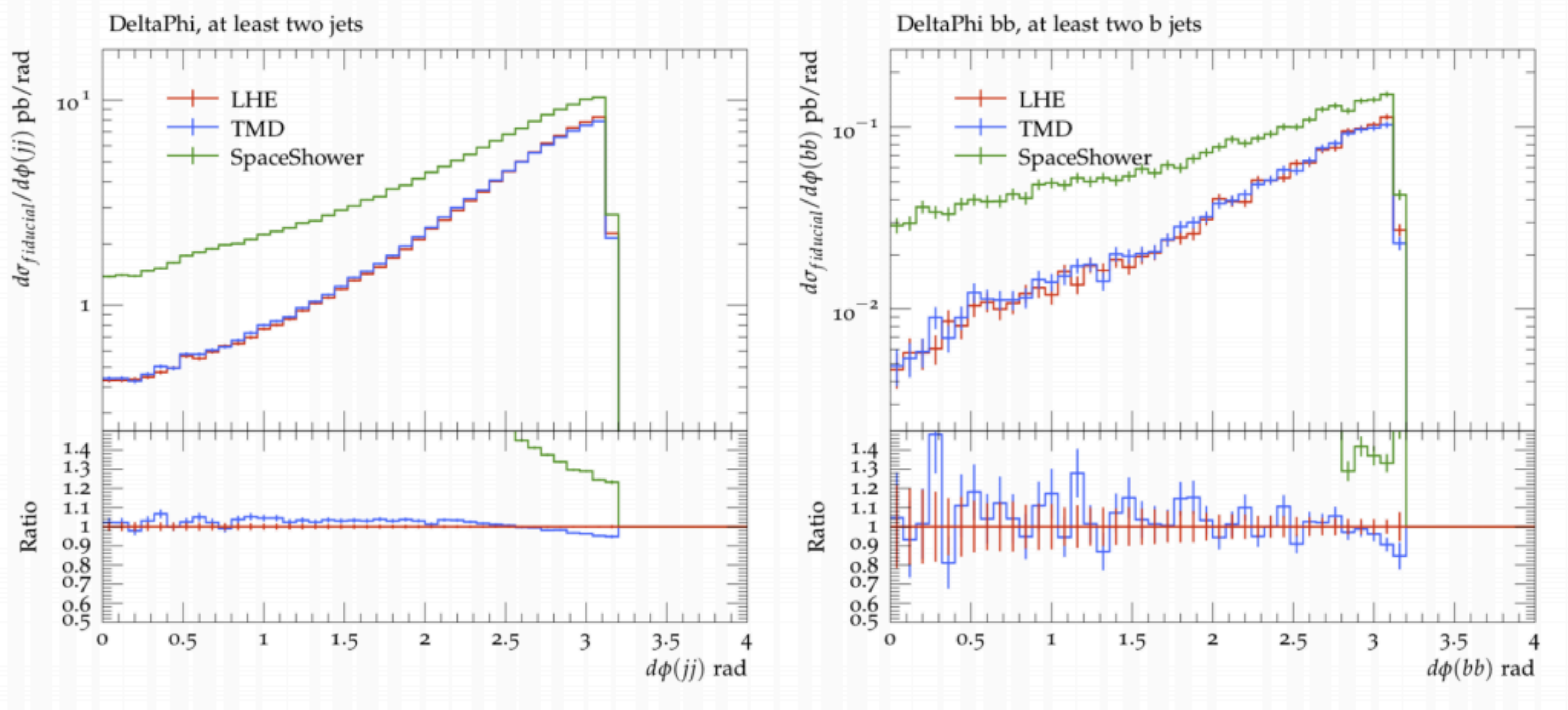
- Good description in the back-to-back region where TMD effects are relevant.
- Decorrelation comes essentially from the kT in the initial evolution.
- From the difference between the distributions we can clearly see the contribution from the b-quark content of the proton.
- Scale uncertainty dominates.

$Z + 2b$ jets: initial state shower



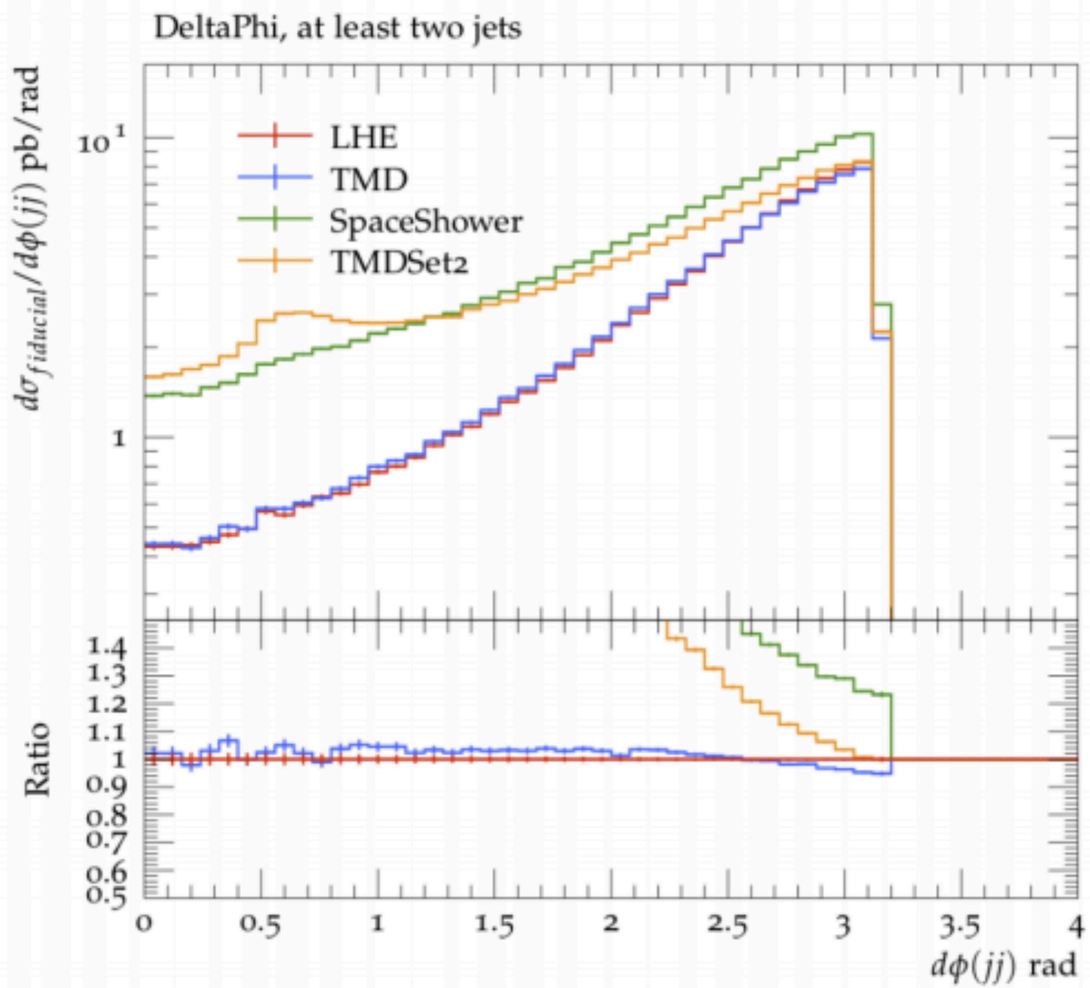
- **TMD** has almost no impact on $\Delta\phi$

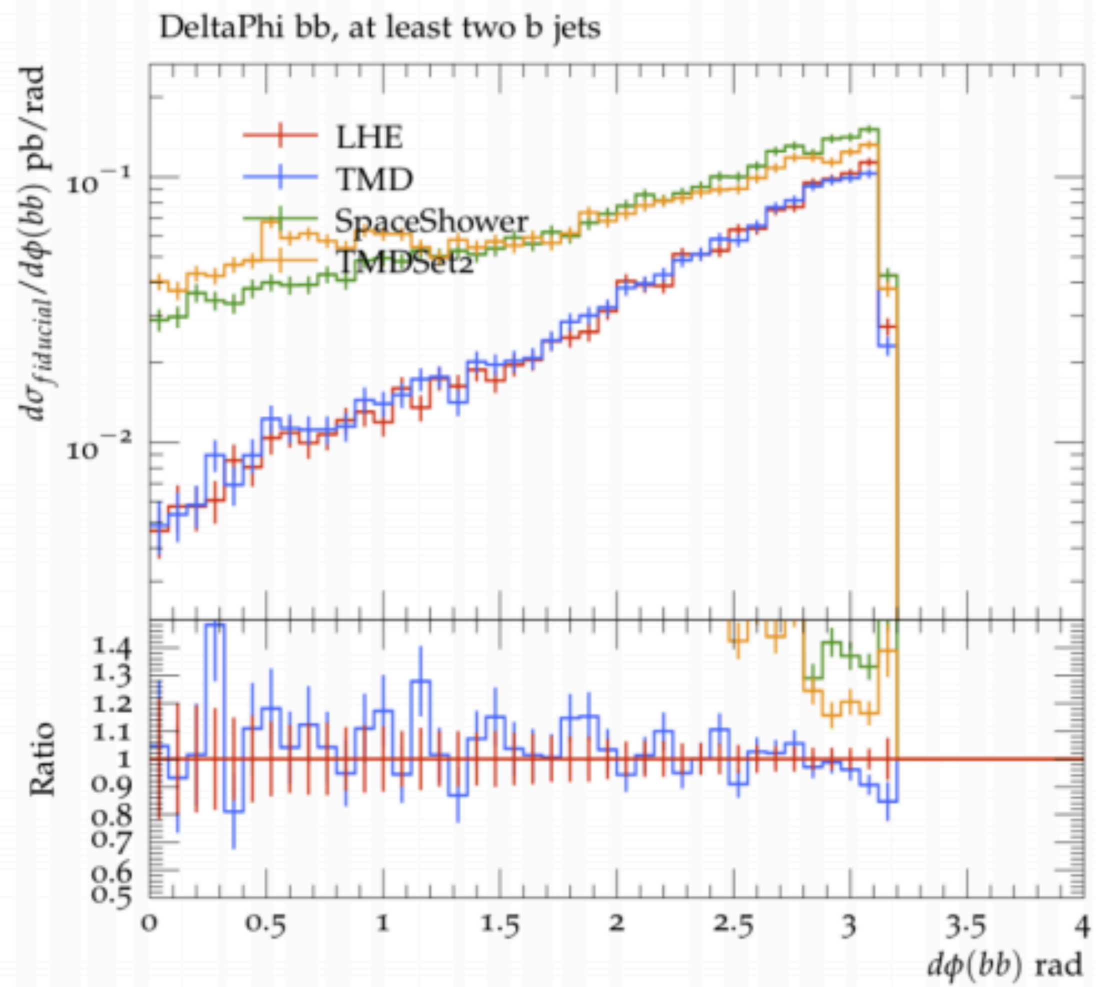
$Z + 2b$ jets: initial state shower



- **SpaceShower** (ISR) has a large effect (on top of **TMD**)

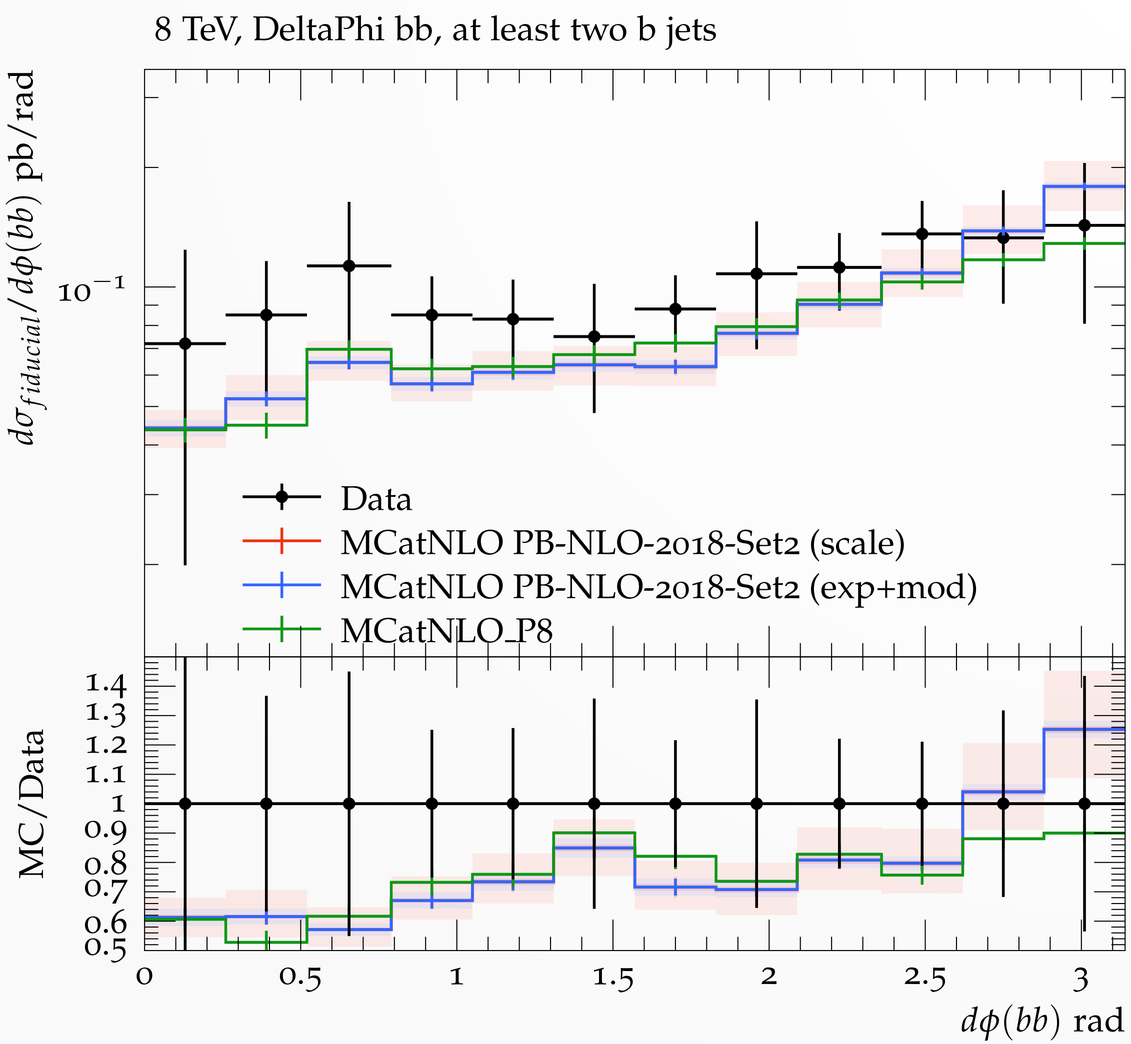
$Z + 2b$ jets: initial state shower





- Time shower (FSR) significant at small $\Delta\phi \rightarrow bb$

$Z + 2b$ jets: initial state shower



- Good description in the back-to-back region where TMD effects are relevant.
- Decorrelation comes essentially from the kT in the initial evolution.
- Space shower (ISR) is important
- Time shower (FSR) only at small $\Delta\phi$(bb)
- Scale uncertainty dominates.

Sensitive to b-quark TMD density and b-quark TMD shower

bb correlation tests space shower

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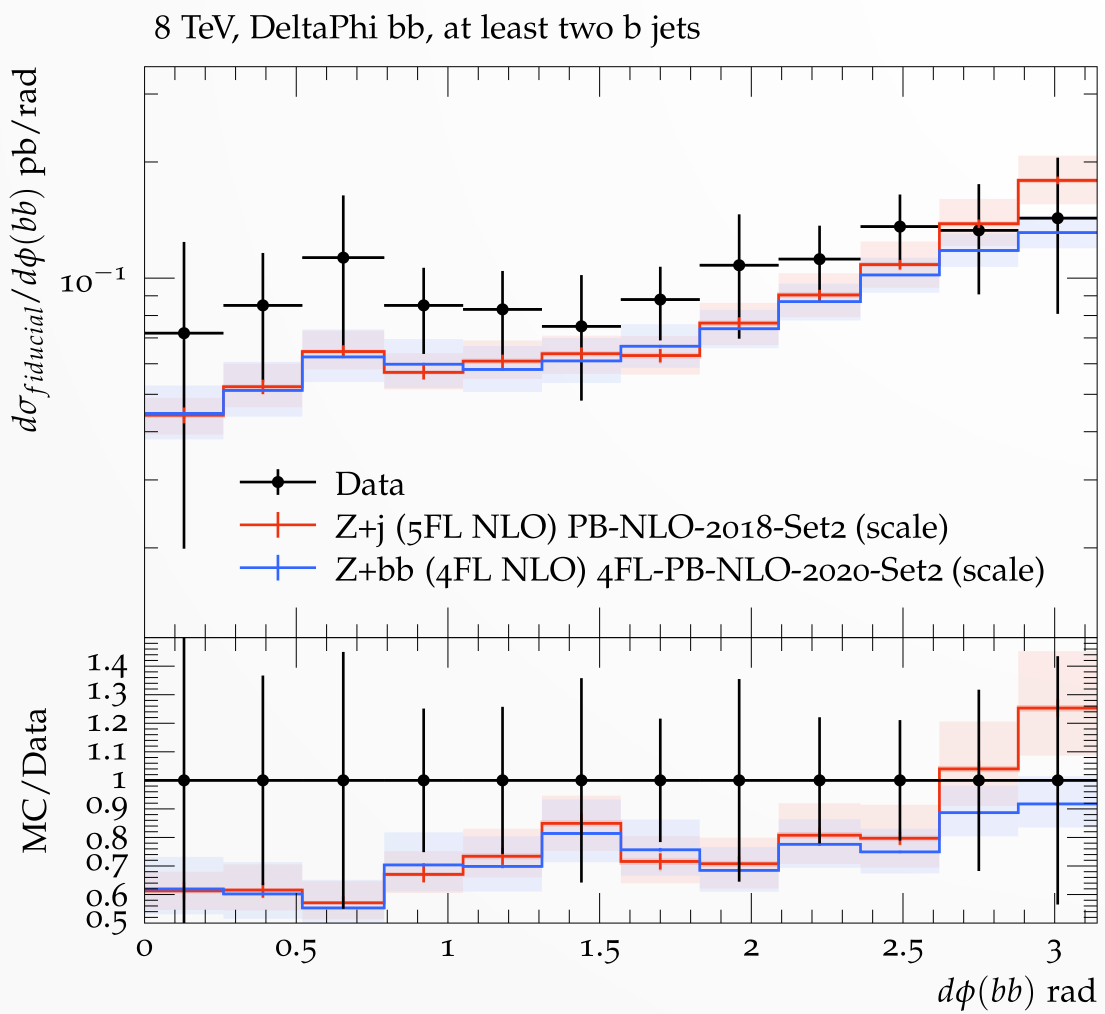
$Z + 2b$ jets: initial state shower



- Good description in the back-to-back region where TMD effects are relevant.
- Decorrelation comes essentially from the kT in the initial evolution.
- Nice consistency between 5FL and 4FL schemes.

Conclusions

- New application to Z + b jets with 4FL and 5FL scheme.
- Distributions well described (scale uncertainty dominates over experimental uncertainties)
- Regions of sensitivity to TMD and space shower (ISR) identified:
  - B-quark TMD density AND b-quark TMD shower.
- Z + b jets interesting analysis for studying initial state parton radiation in very detail: TMDs and TMD showers.