Validation of bias weighting

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Introduction

- Bias weight function in aMC@NLO allows us to generate more events in a particular area of phase space of an inclusive sample (at LHE-level)
  - Saves having to stitch e.g. inclusive and p_T binned samples together
- We want to apply this to DY+up to 2 jets (and W+up to 2 jets)
  - Start validation with DY+ up to 1 jet as this can be run locally (ie DY +0 and DY+1)
- In these slides: validation with a total of 100k LHE events for several scenarios*:
  - **No bias weight** (unbiased, default aMC@NLO production)
  - **Biased, function 1:** $(25+(Z\ p_T)^2)*10^{njets}$ (This from the example bias weight cards)
    - As we will see this function really weights down the 0-jet events so much that the uncertainties on these events become very large. Try to mitigate this by:
  - **Biased, function 2:** $1000 + (Z\ p_T)^2*10^{njets}$
  - **Biased, function 3:** $1000 + [(Z\ p_T)^3*10^{njets}]/1000$

*cards:

unbiased: https://github.com/adewit/genproductions/tree/bias-cards/bin/MadGraph5_aMCatNLO/cards/examples/dyellell01j_5f_NLO_FXFX
bias function 1: https://github.com/adewit/genproductions/tree/bias-cards/bin/MadGraph5_aMCatNLO/cards/examples/dyellell01j_5f_NLO_FXFX_bias
bias function 2: https://github.com/adewit/genproductions/tree/bias-cards/bin/MadGraph5_aMCatNLO/cards/examples/dyellell01j_5f_NLO_FXFX_bias_2
bias function 3: https://github.com/adewit/genproductions/tree/bias-cards/bin/MadGraph5_aMCatNLO/cards/examples/dyellell01j_5f_NLO_FXFX_bias_3

Settings

- **Note:** I reduced the integration grid accuracy from the default to speed the process up a bit. Should not affect the global picture we get from these slides
- **PYTHIA fragment:**

```
processParameters = cms.vstring(
        'JetMatching:setMad = off',
        'JetMatching:scheme = 1',
        'JetMatching:merge = on',
        'JetMatching:jetAlgorithm = 2',
        'JetMatching:etaJetMax = 999.',
        'JetMatching:coneRadius = 1.',
        'JetMatching:slowJetPower = 1',
        'JetMatching:qCut = 30.', #this is the actual merging scale
        'JetMatching:doFxFx = on',
        'JetMatching:qCutME = 10.',#this must match the ptj cut in the lhe generation step
        'JetMatching:nQmatch = 5', #4 corresponds to 4-flavour scheme (no matching of b-quarks), 5 for 5-flavour
scheme
        'JetMatching:nJetMax = 1', #number of partons in born matrix element for highest multiplicity
    ),
```

- I realise "TimeShower:mMaxGamma = 4.0" is missing from the fragment. Will fix this for future studies.

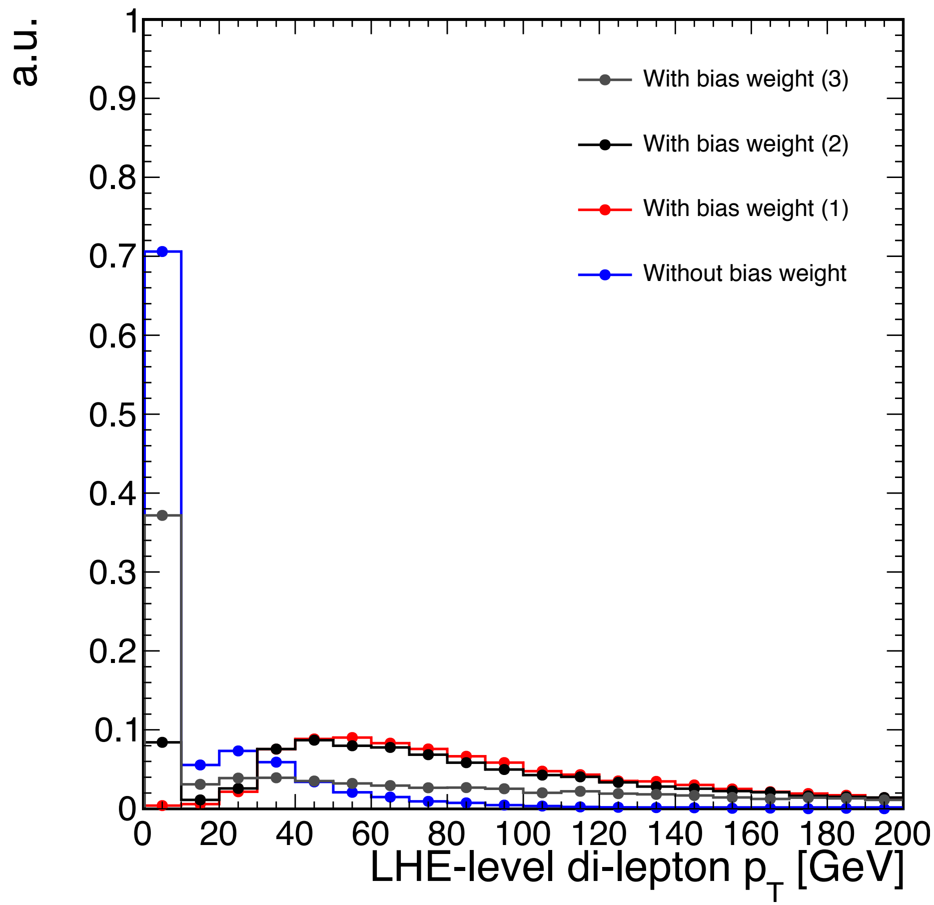
PYTHIA shower matching efficiency

- Before comparing distributions, have a look at the matching efficiency reported by PYTHIA

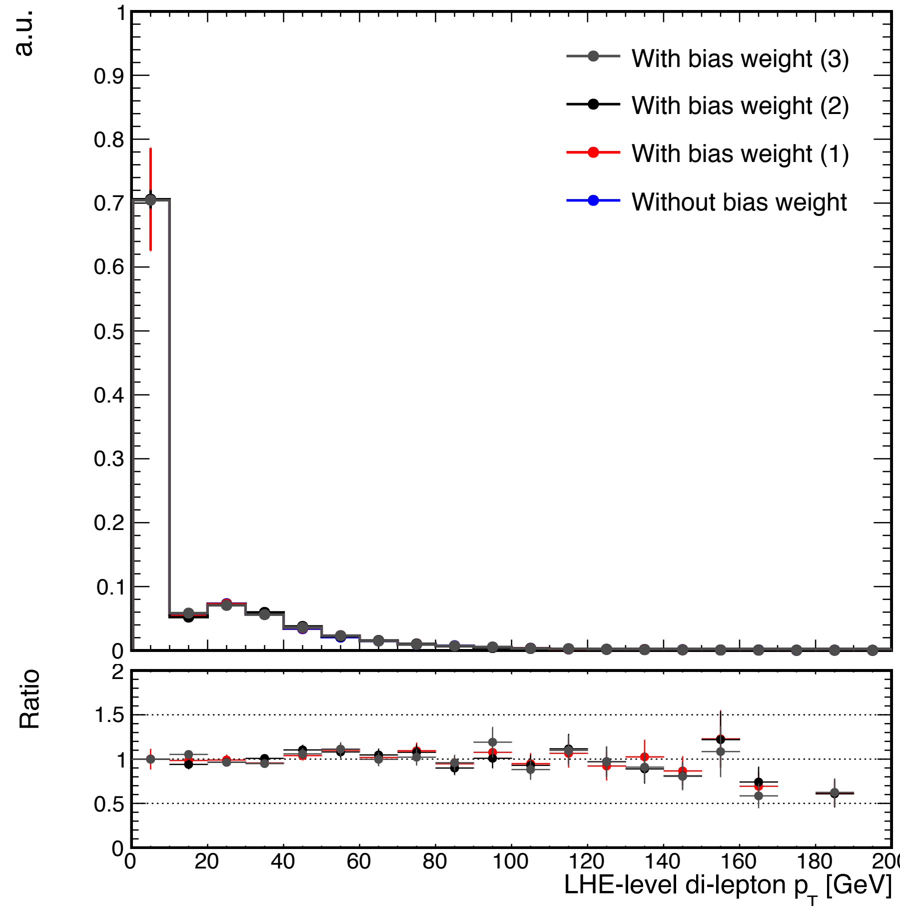
	N_{evts} tried	N_{evts} accepted	N_{evts} tried, 0-jet	N_{evts} accepted, 0-jet	N_{evts} tried, 1-jet	N_{evts} accepted, 1-jet
No bias weight	100000	51836	42230	36901	57770	14935
Function 1	100000	74147	3239	635	96761	73512
Function 2	100000	72419	7945	4981	92055	67438
Function 3	100000	66347	26580	22117	53130	44230

Function 1 leads to a vast reduction in the number of 0-jet events at LHE level. The other two functions also reduce the number of 0-jet events (expected as LHE Z p_T is 0 in such events) - but due to larger constant term in the function the reduction isn't as pronounced. This is important for the uncertainties on 0-jet events.

LHE-level comparisons: Z p_T



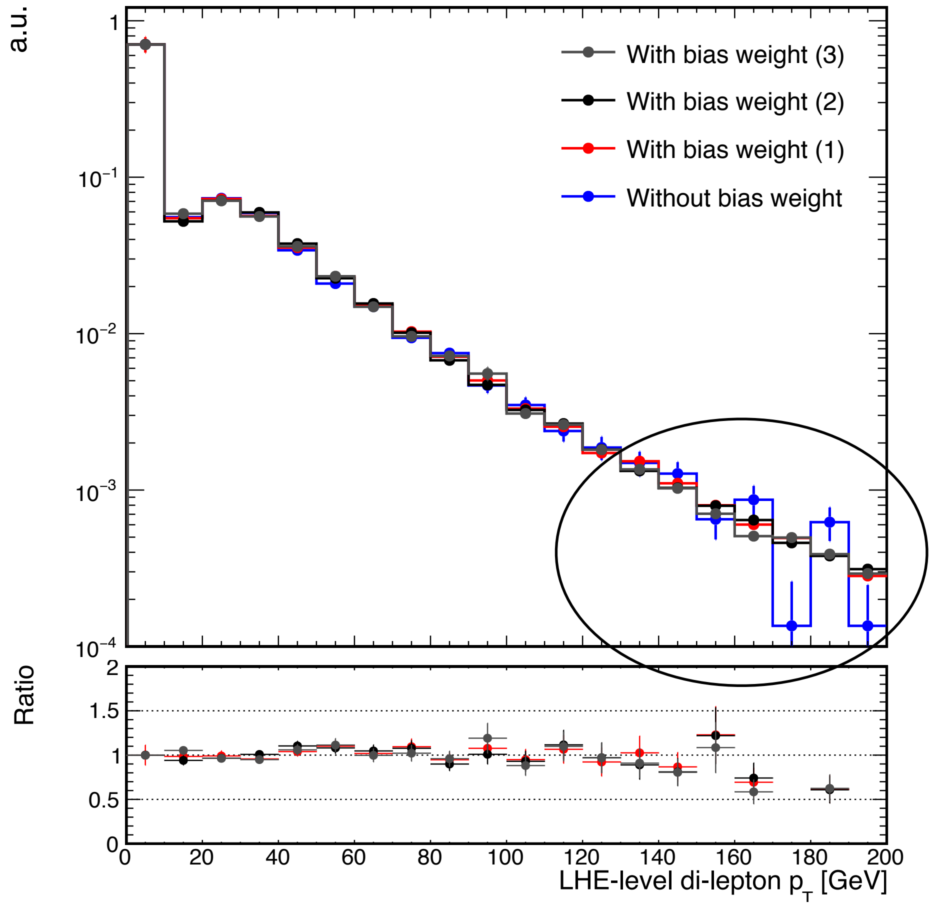
Only the sign of the weight applied (gives ~effective distribution)



Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

Here we see the behaviour that function 1 leads to very large weights at very low LHE p_T (0 jet evts)

LHE-level comparisons: Z p_T



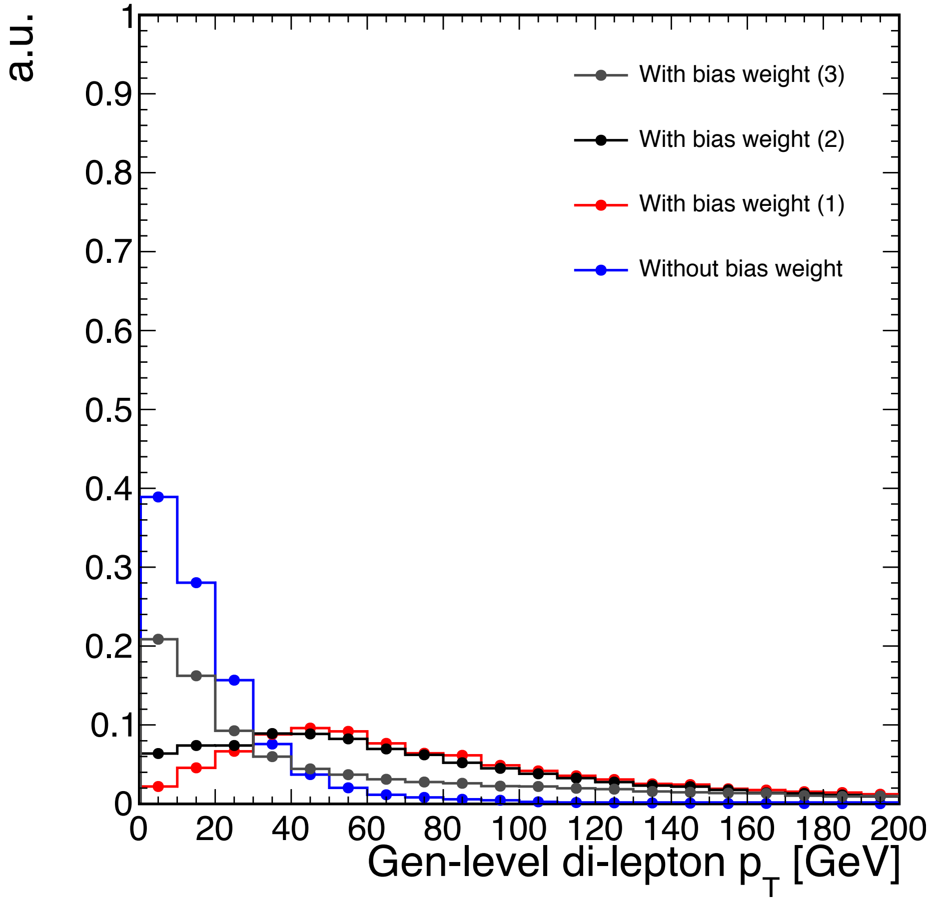
Biased events give a visibly smoother tail here

Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

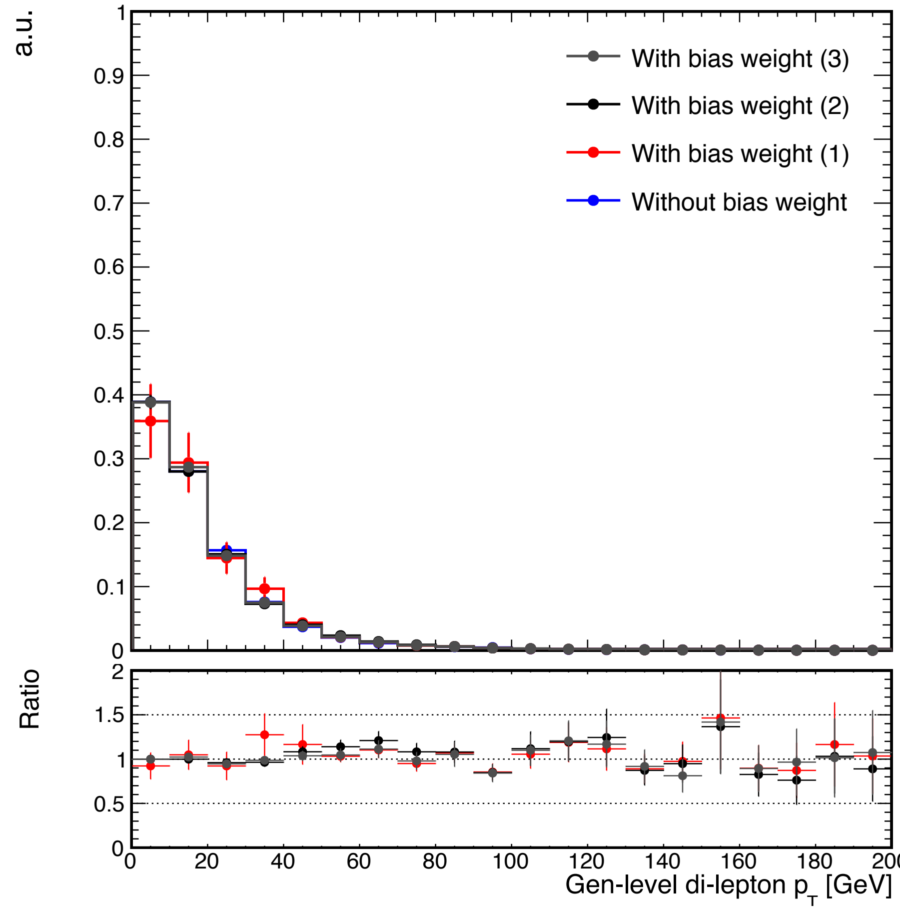
Gen-level comparisons

- Next few slides show ~same comparisons, but now using gen-level quantities (ie post-shower)
  - Di-lepton p_T and mass calculated using leptons from the genParticle collection, which satisfy:
    - **Electrons/Muons:** status flag IsPrompt **OR** IsDirectPromptTauDecayProduct, in addition status flag IsLastCopy
    - **Hadronic taus:** rebuild the hadronic taus by summing four-vectors of gen-level tau decay products (unless the tau decays leptonically).

Gen-level comparisons: Z p_T



Only the sign of the weight applied (gives ~effective distribution)



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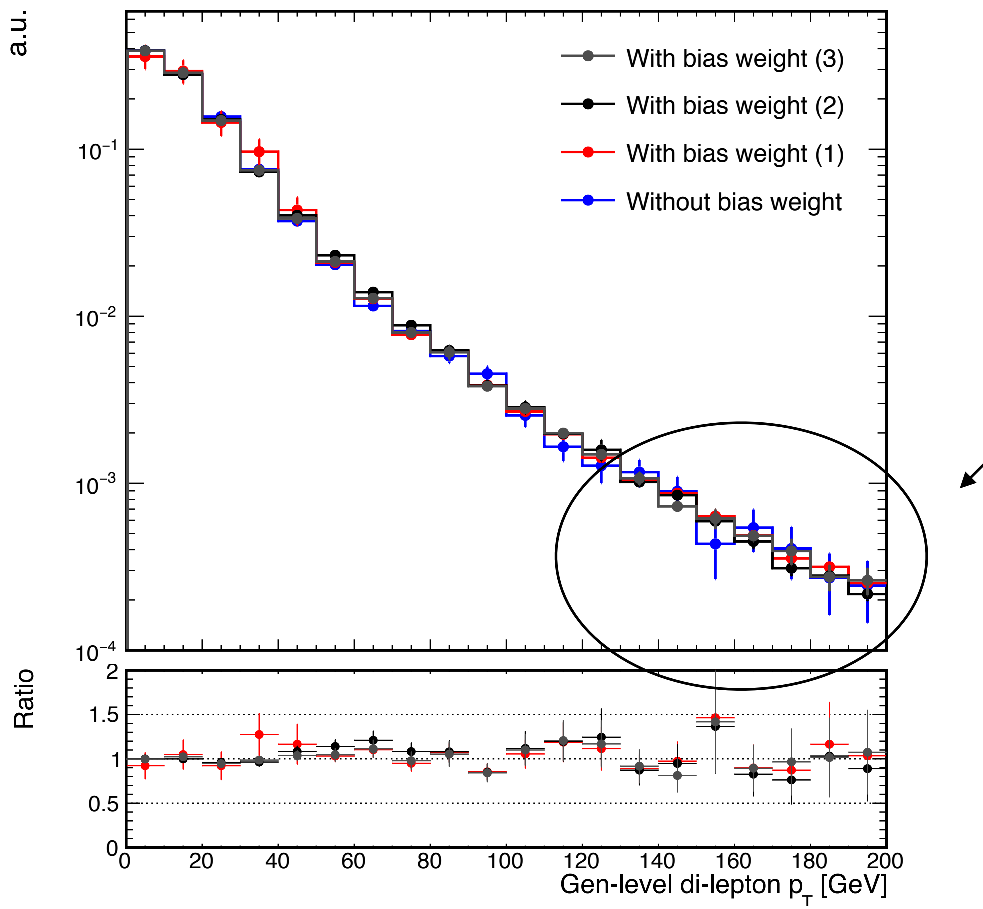
Gen-level comparisons: Z p_T



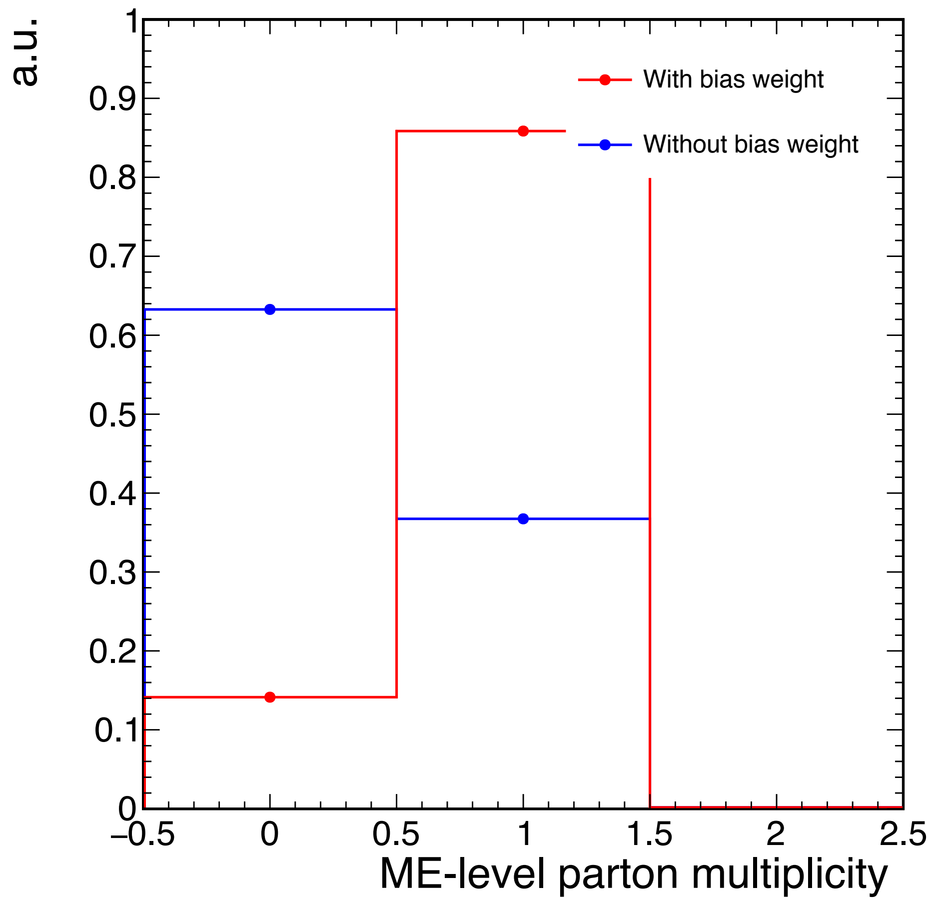
Biased events have smaller uncertainties in the tail

Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

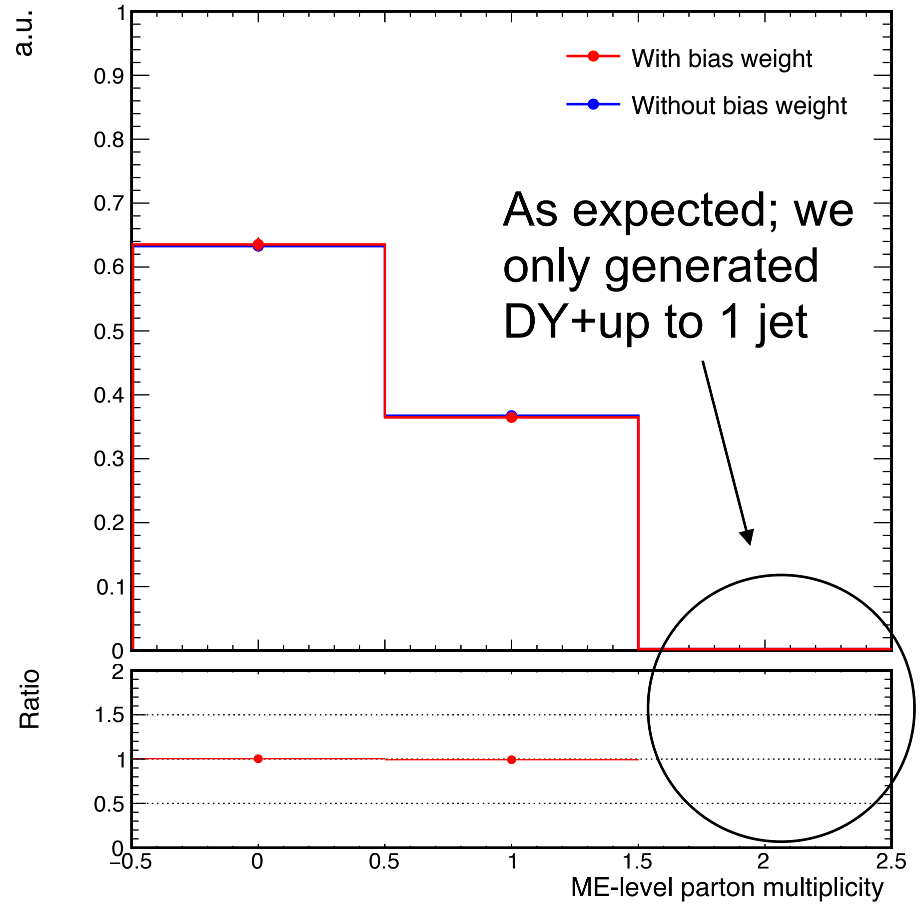
Jet/parton multiplicity

- Should also check the gen jet and parton multiplicity
- Several variables to plot:
  - Number of gen jets
  - Number of partons (#of LHE particles with status 1 and pdgid 1-6 or 21)
  - Number of partons in the matrix element (the npNLO-tag written into the LHE-file)
- In the following slides, just use bias function 2 and the unbiased events for clarity

npNLO (DY)

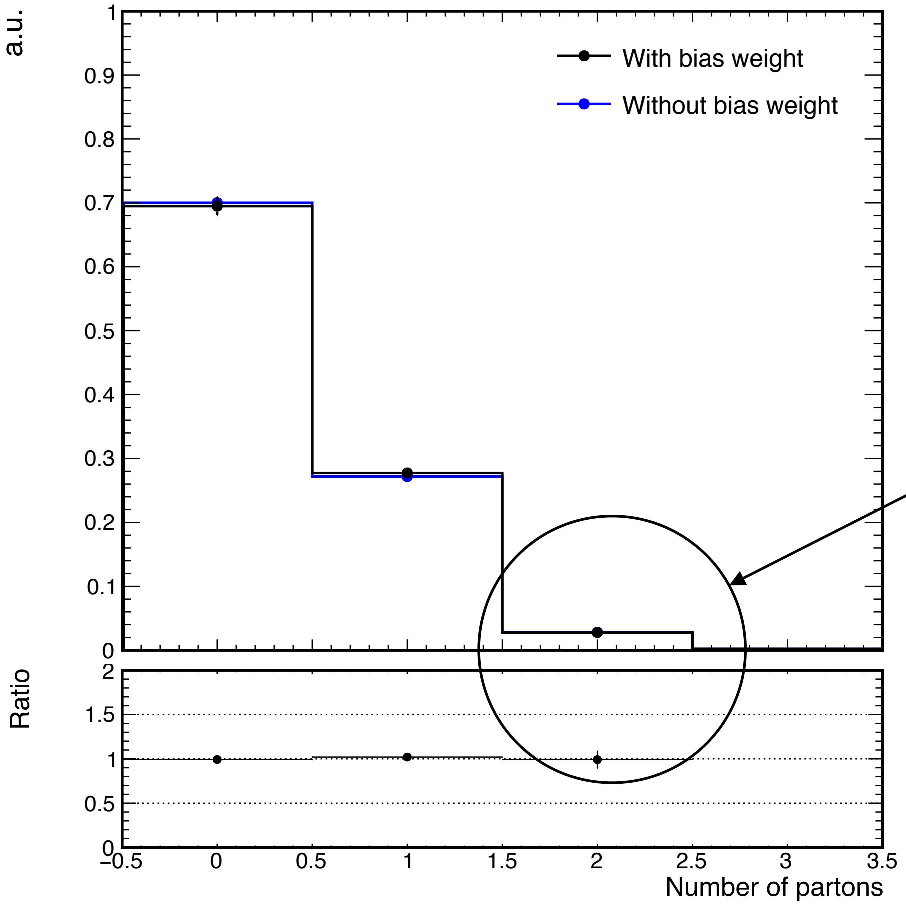


Only the sign of the weight applied (gives ~effective distribution)



Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

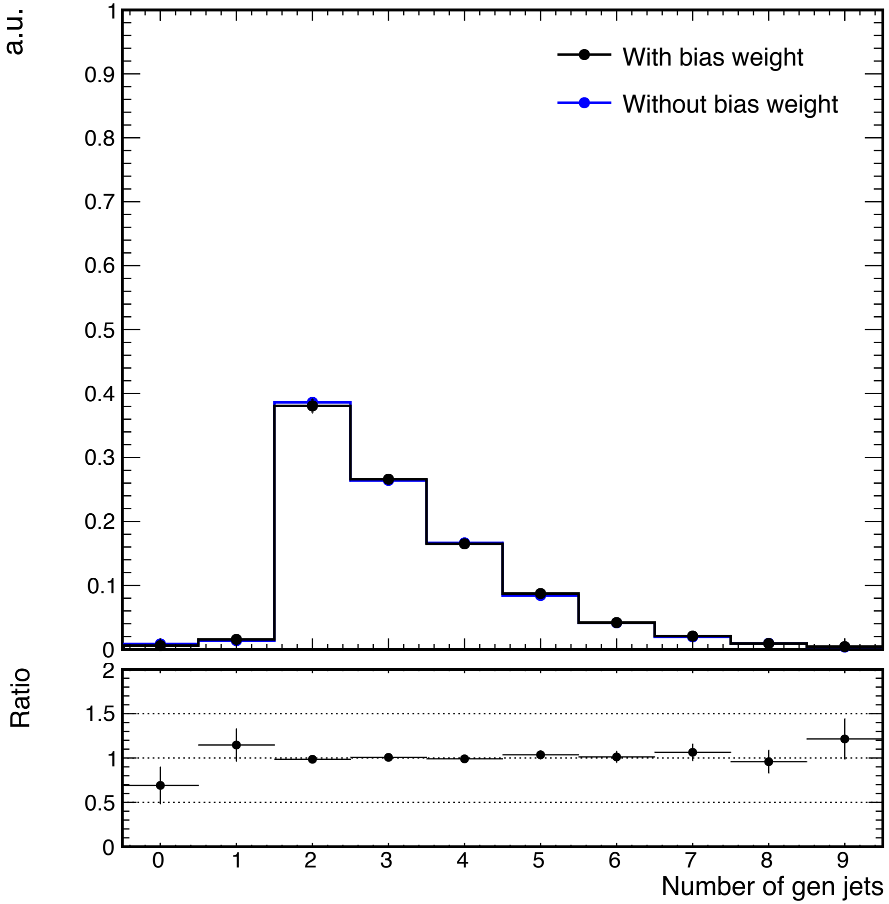
#LHE partons (DY)

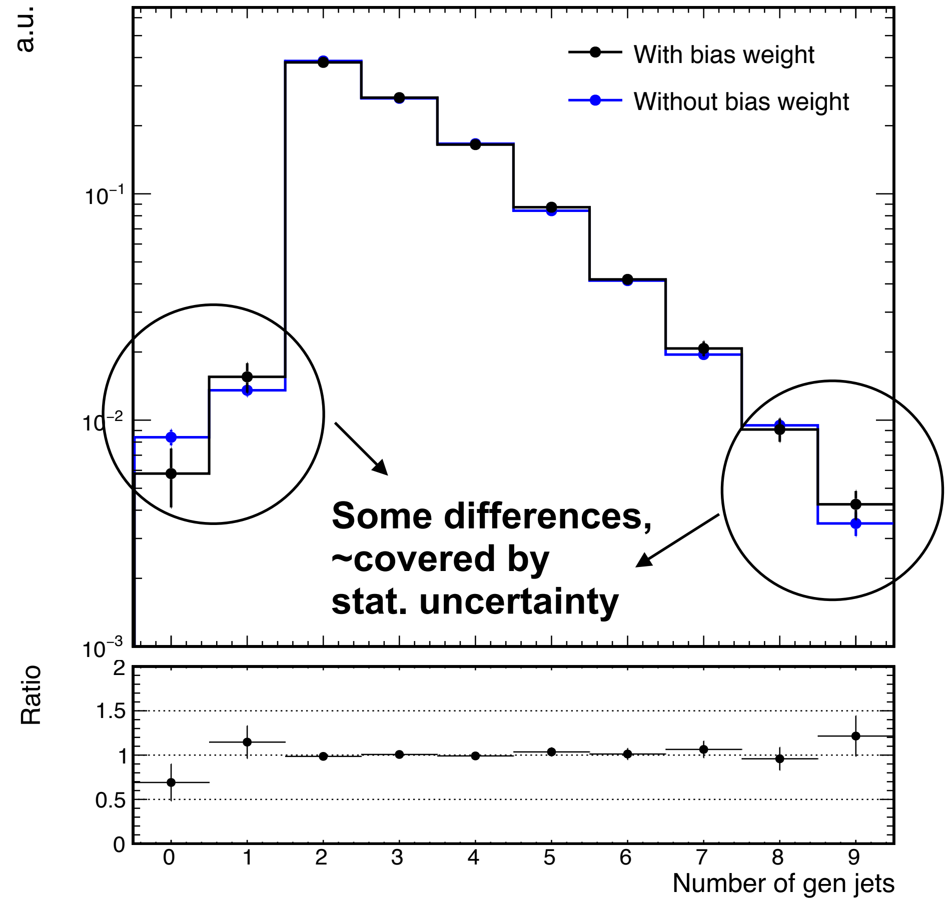


In some cases we end up with an additional parton (on top of the # used in the ME)

Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

#gen jets (DY)





Full weight applied (ie including bias weights)
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Note: ratio taken with respect to default, unbiased sample (in blue)

W+Jets validation

- Also check the behaviour in W+jet events
  - Similar setup as for DY: use W+ up to 1 jet, 100k LHE-events for each
  - Use the same bias function #2 as used for DY: $1000 + (W\ p_T)^2 * 10^{njets}$
    - W p_T of course calculated as (lepton+neutrino) p_T
- So far only showing LHE-level p_T distribution and checks on the number of jets/partons
  - Reason for this is purely technical, code needs some rewriting to be able to plot gen-level (post-shower) p_T

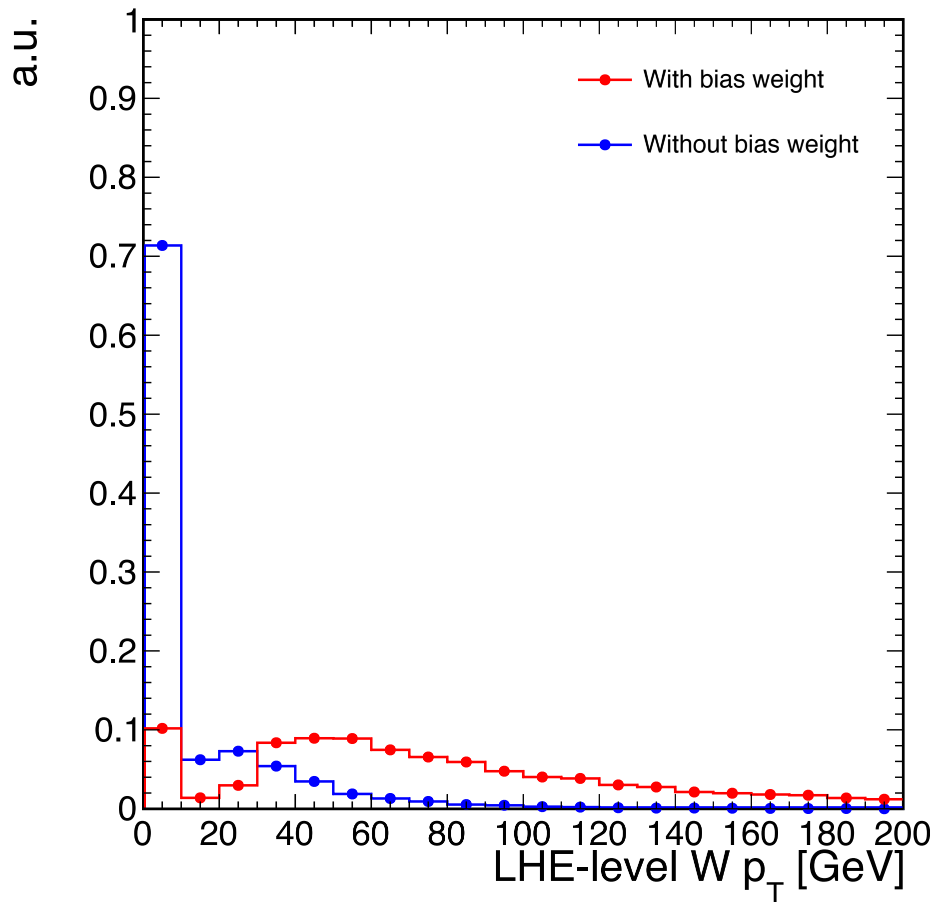
PYTHIA shower matching efficiency

- Before comparing distributions, have a look at the matching efficiency reported by PYTHIA

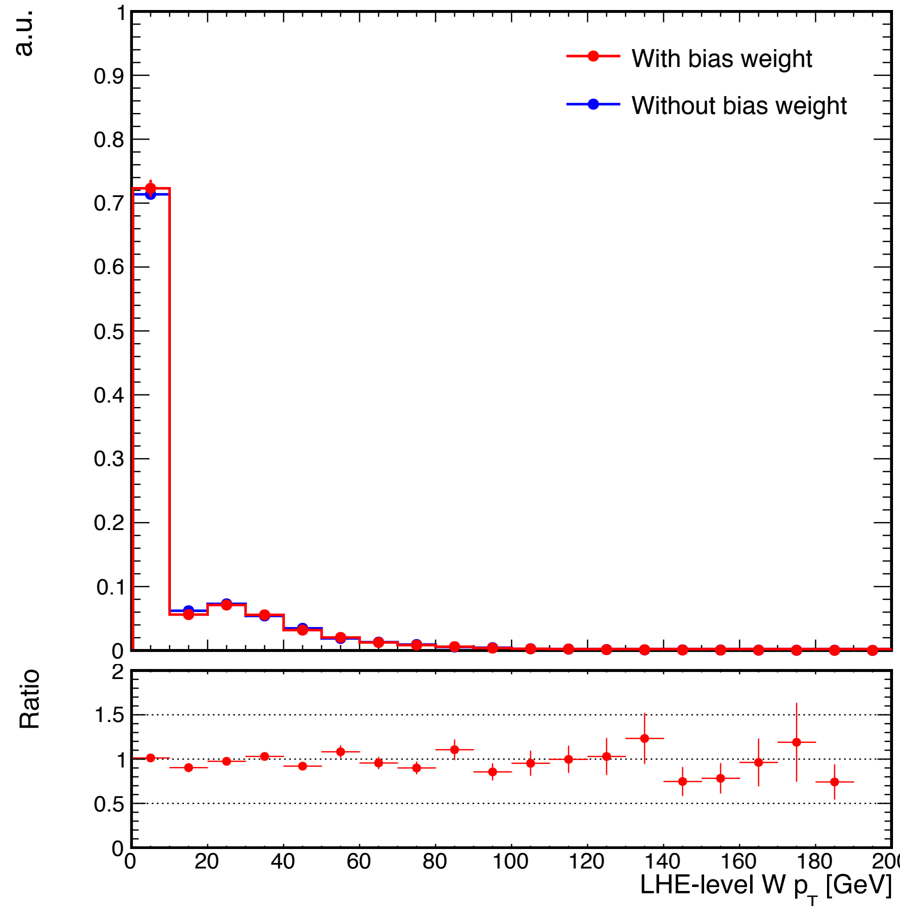
	N_{evts} tried	N_{evts} accepted	N_{evts} tried, 0-jet	N_{evts} accepted, 0-jet	N_{evts} tried, 1-jet	N_{evts} accepted, 1-jet
No bias weight	100000	52874	43671	38977	56329	13897
With bias weight function	100000	70588	8493	5752	91507	64836

	N_{evts} tried, 0-jet, +ve lep	N_{evts} accepted, 0-jet +ve lep	N_{evts} tried, 0-jet -ve lep	N_{evts} accepted, 0-jet -ve lep	N_{evts} tried, 1-jet +ve lep	N_{evts} accepted, 1-jet +ve lep	N_{evts} tried, 1-jet -ve lep	N_{evts} accepted, 1-jet -ve lep
No bias weight	25176	22477	18495	16500	32193	8097	16467	5800
With bias weight function	4881	3294	3612	2458	53709	38330	37798	26506

LHE-level comparisons: W p_T



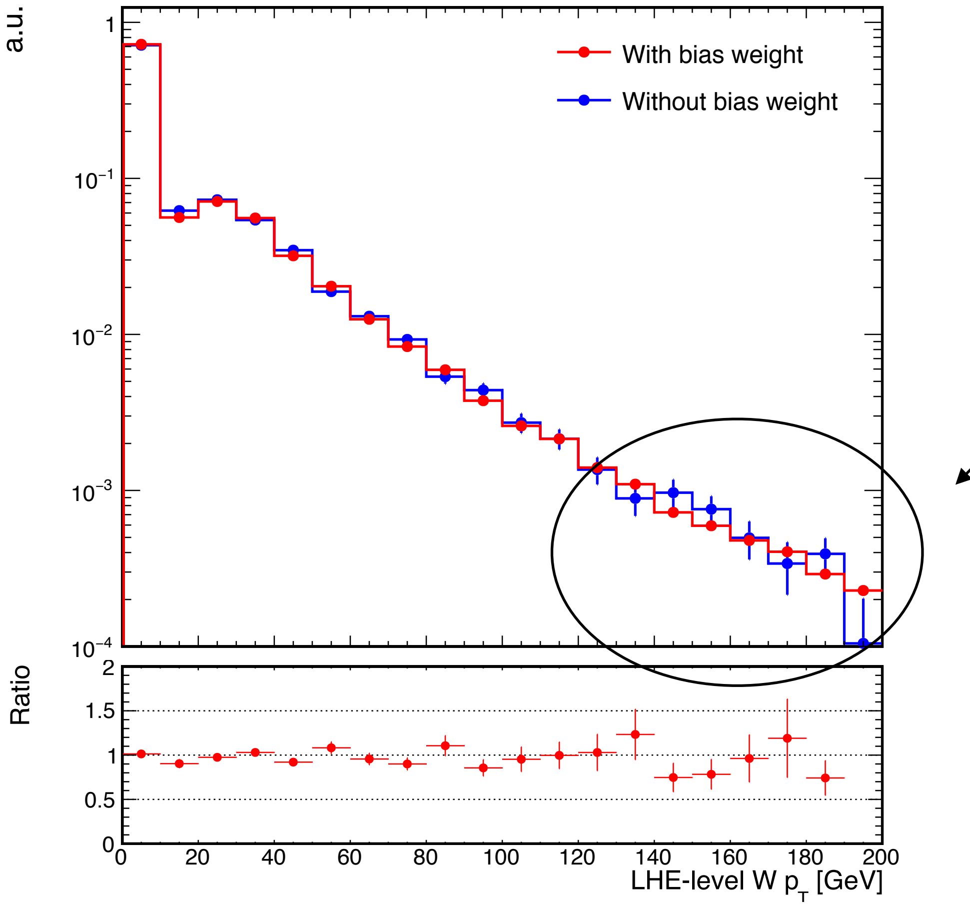
Only the sign of the weight applied (gives ~effective distribution)



Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

Ratio of biased/unbiased distribution: similar level of discrepancy as in DY, mostly covered by stat. uncertainty

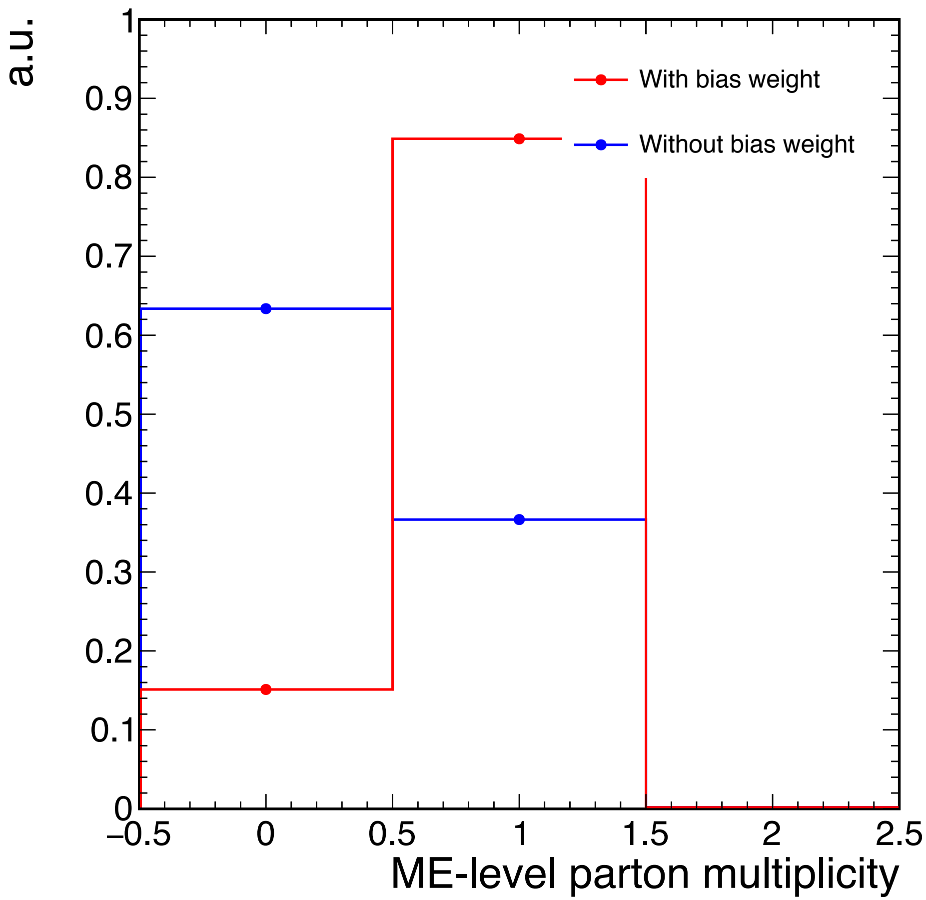
LHE-level comparisons: W p_T



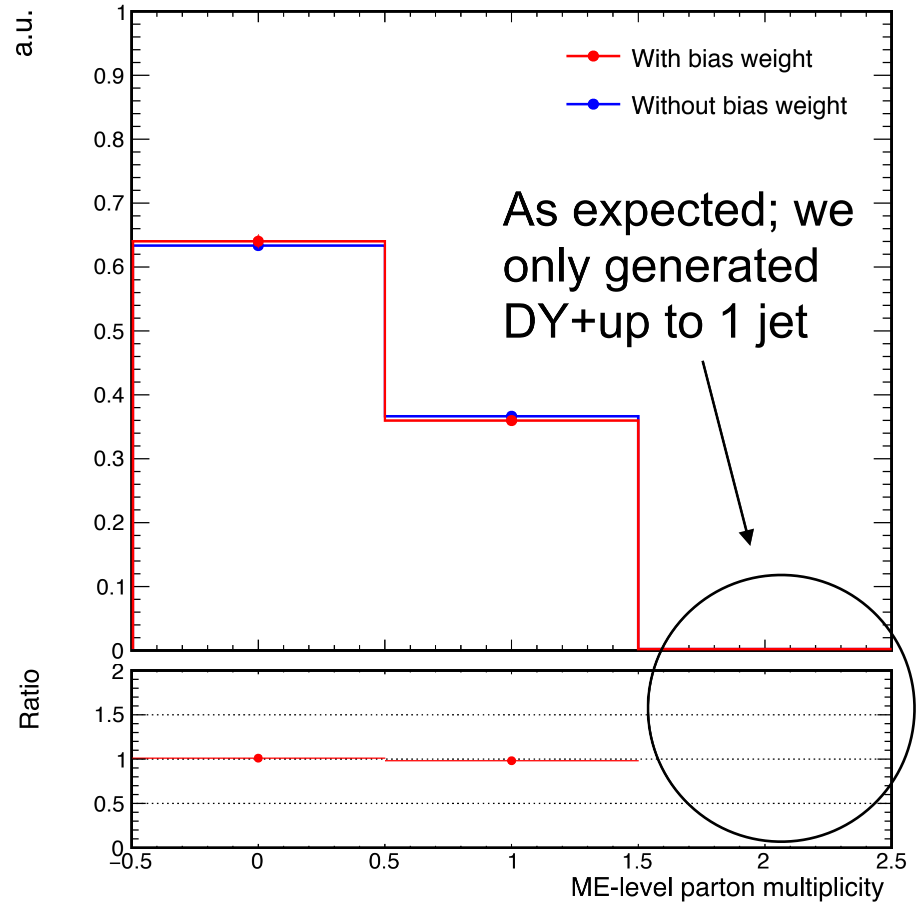
Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

Biased events give a visibly smoother tail here

npNLO (W)

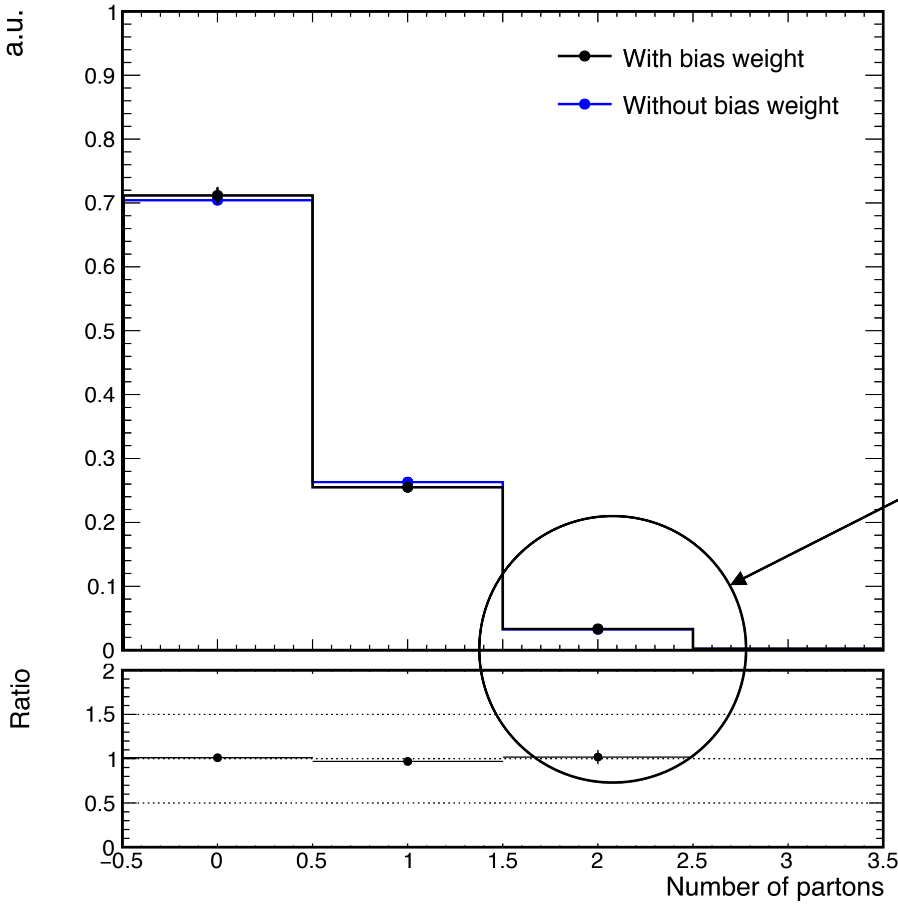


Only the sign of the weight applied (gives ~effective distribution)



Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

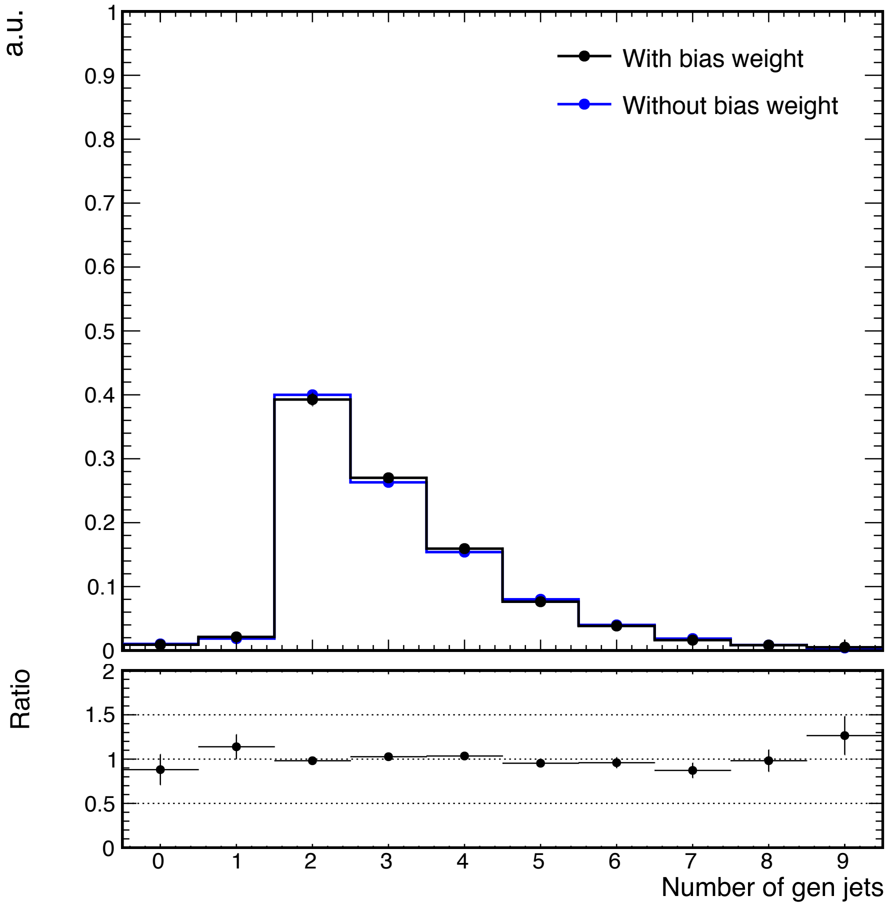
#LHE partons (W)

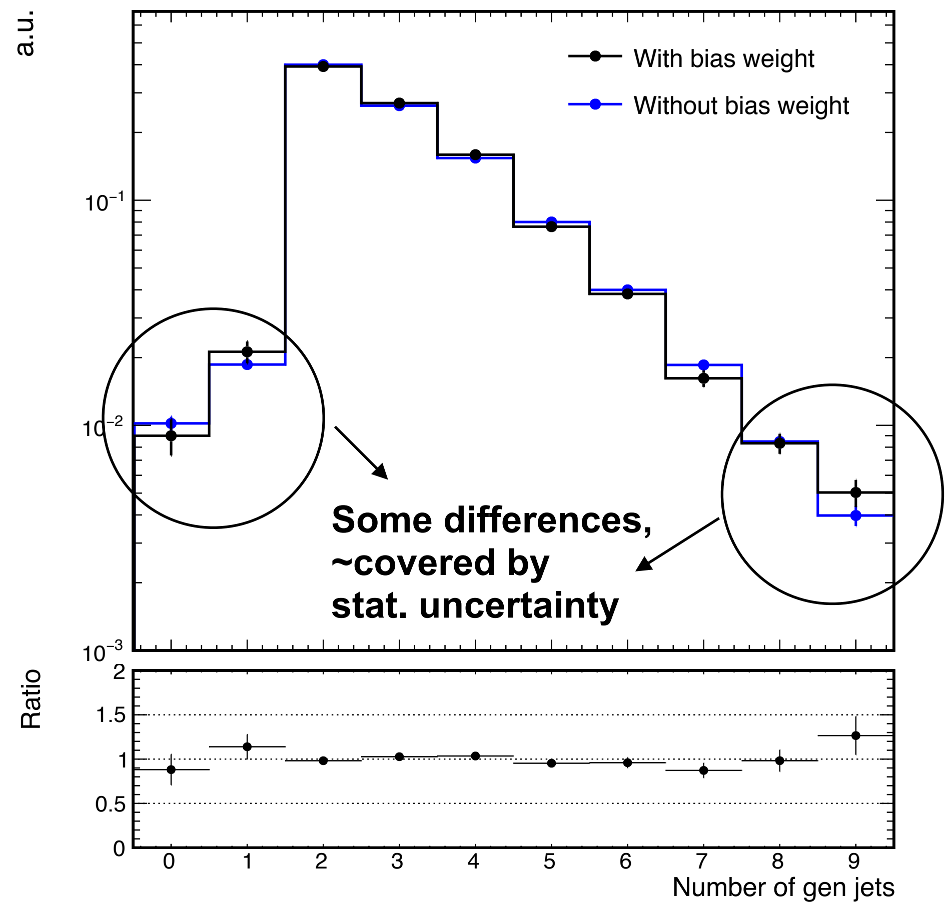


In some cases we end up with an additional parton (on top of the # used in the ME)

Full weight applied (ie including bias weights)
Note: ratio taken with respect to default, unbiased sample (in blue)

#gen jets (W)





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Summary

- DY validation:
  - **Bias weighting produces good results:**
    - LHE- and gen level di-lepton p_T are compatible between biased and unbiased events
    - Number of partons at LHE/ME level and Number of gen jets also compatible
    - LHE/gen-level di-lepton p_T tails enhanced as expected
- For the W+up to 1 jet process, the picture is largely similar to DY
  - Discrepancies between biased and unbiased distributions perhaps slightly larger, but still compatible