# Studies on the simulation of W+bb production at hadron colliders

Marianna Liberatore

*Supervisors: Federico Sforza & Sandra Leone*

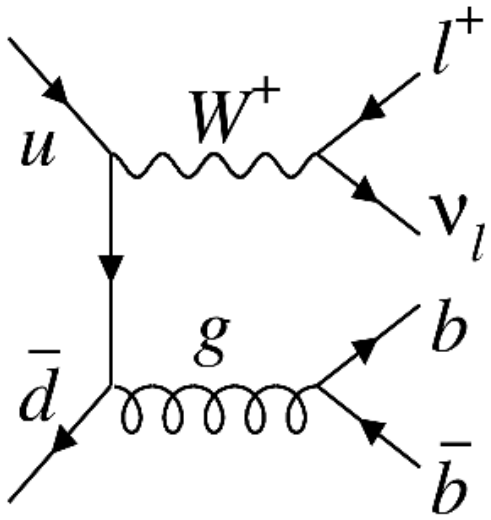
CERN
Université Paris Diderot (Paris 7)

9 August 2016

# Introduction

**What we study**

Interested in the associated production of b quark jets with W vector bosons




An example of Wbb process

**Why?**

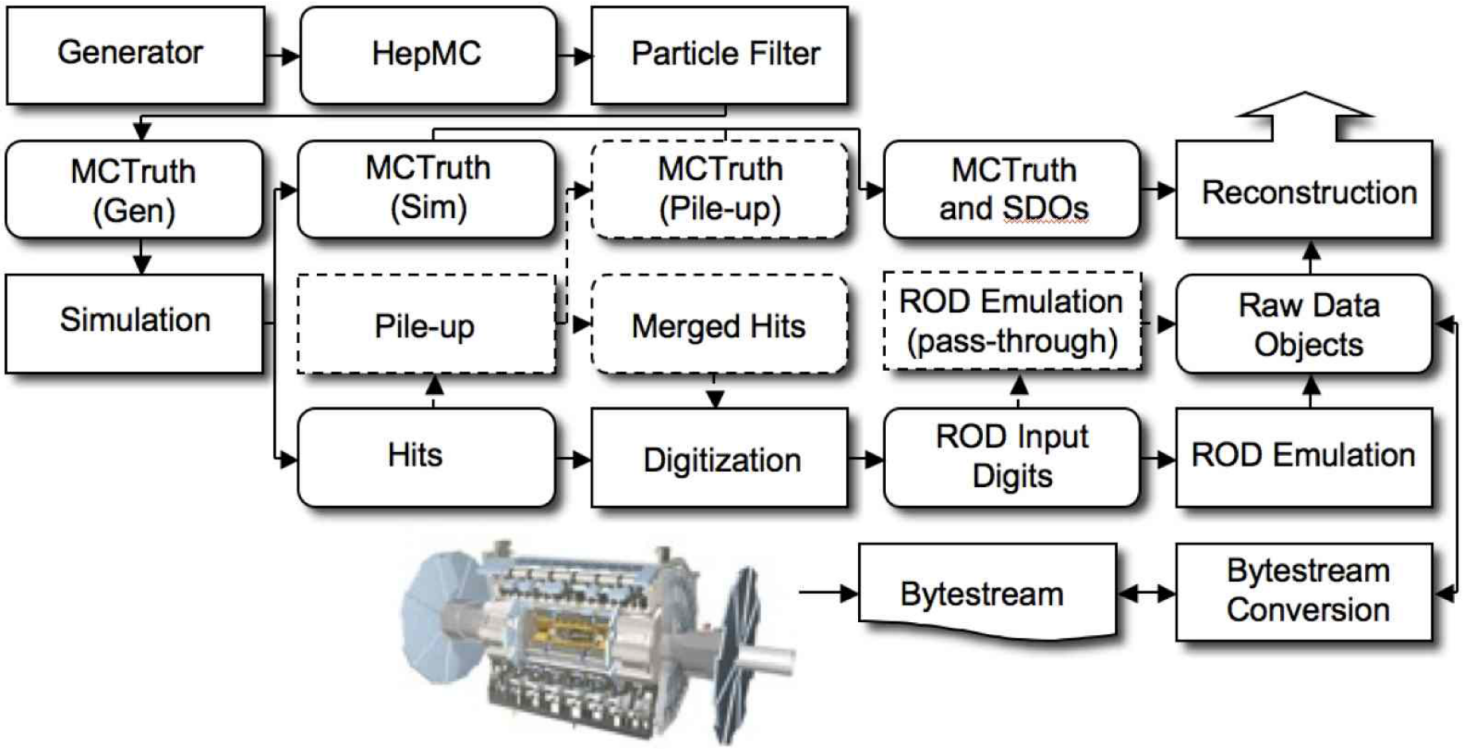
- W/Z+Heavy Flavor quark jets processes are interesting for both Standard Model (SM) and Beyond SM (BSM) physics
- However SM predictions for W/Z+bb are associated with large theoretical uncertainties

# Monte Carlo simulation in "brief"

MC simulation is essential in High Energy Physics to understand such processes

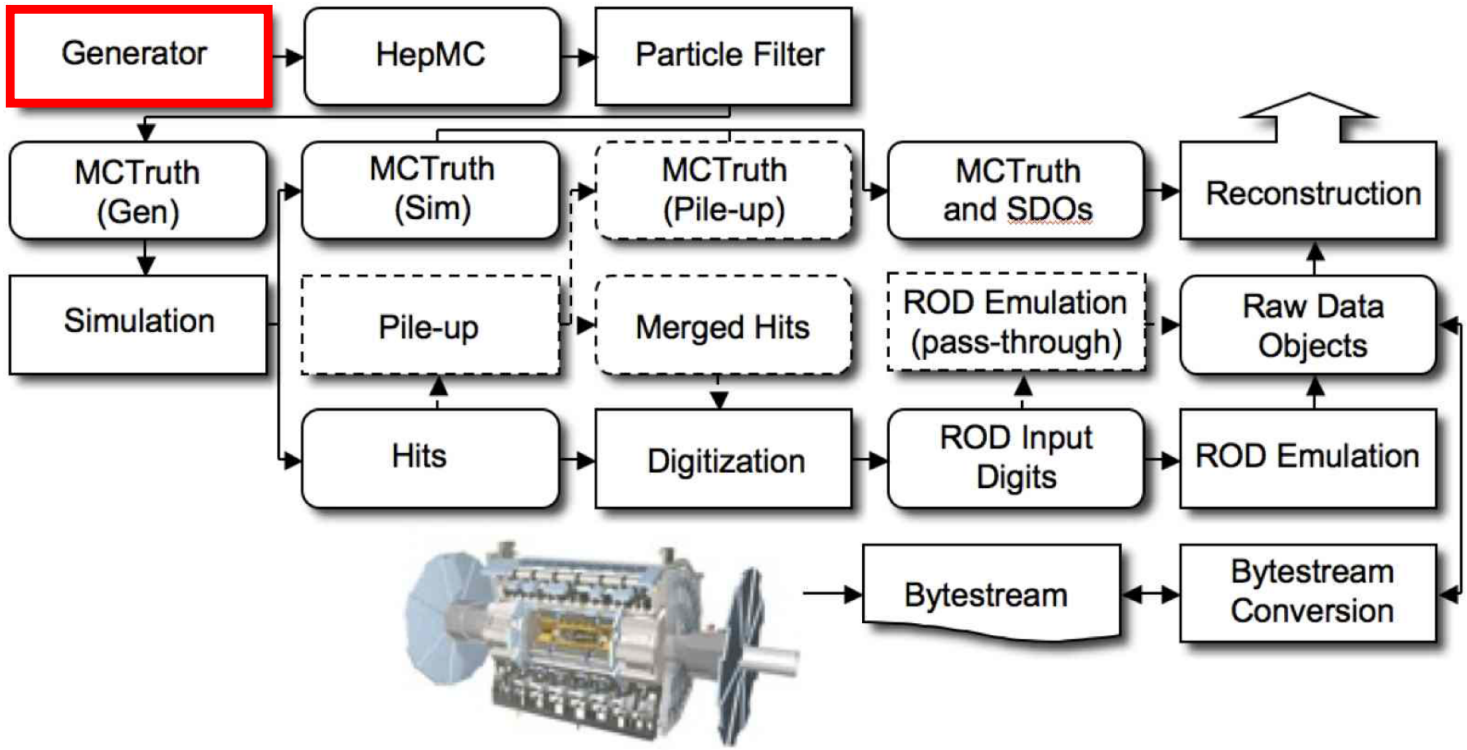
# Monte Carlo simulation in "brief"

MC simulation is essential in High Energy Physics to understand such processes



# Monte Carlo simulation in "brief"

MC simulation is essential in High Energy Physics to understand such processes

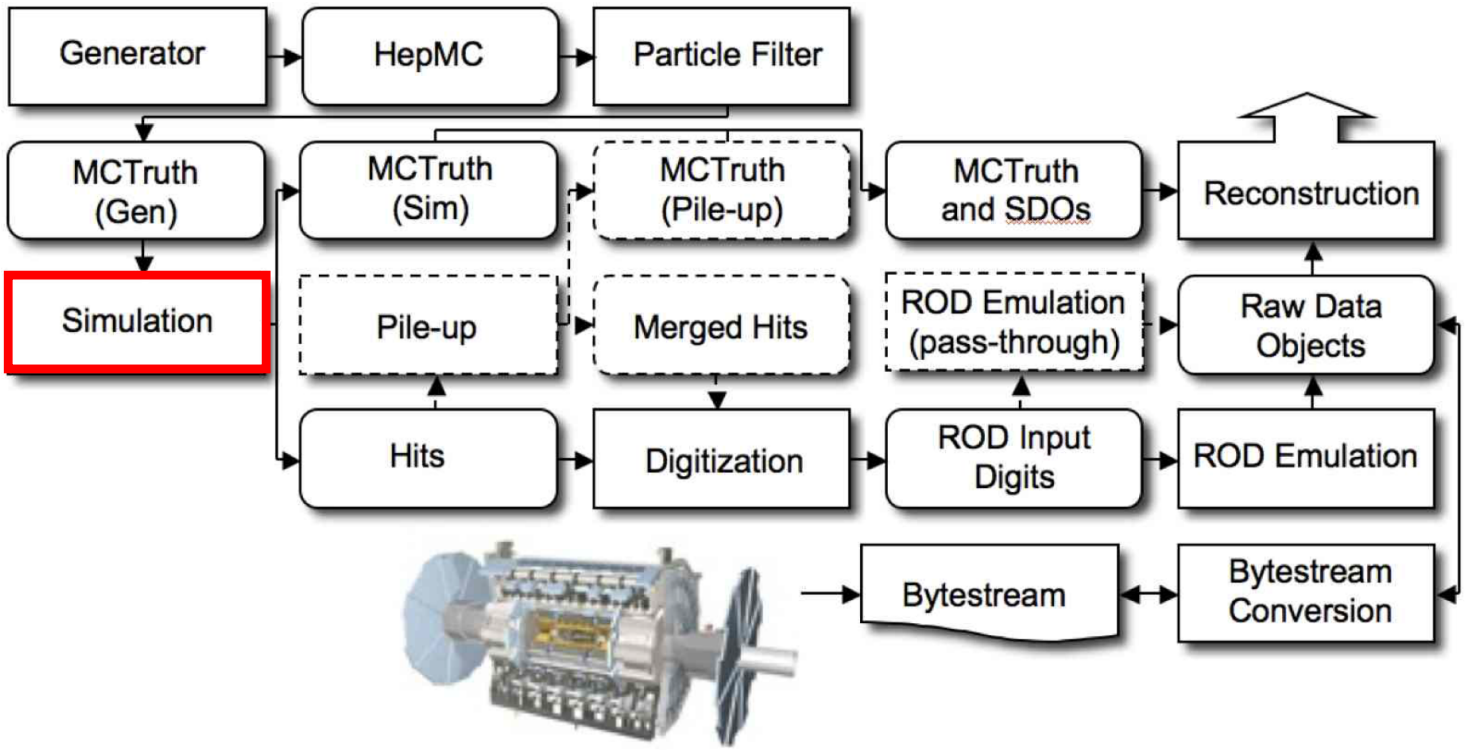



3 main steps in data analysis:

GENERATION

# Monte Carlo simulation in "brief"

MC simulation is essential in High Energy Physics to understand such processes

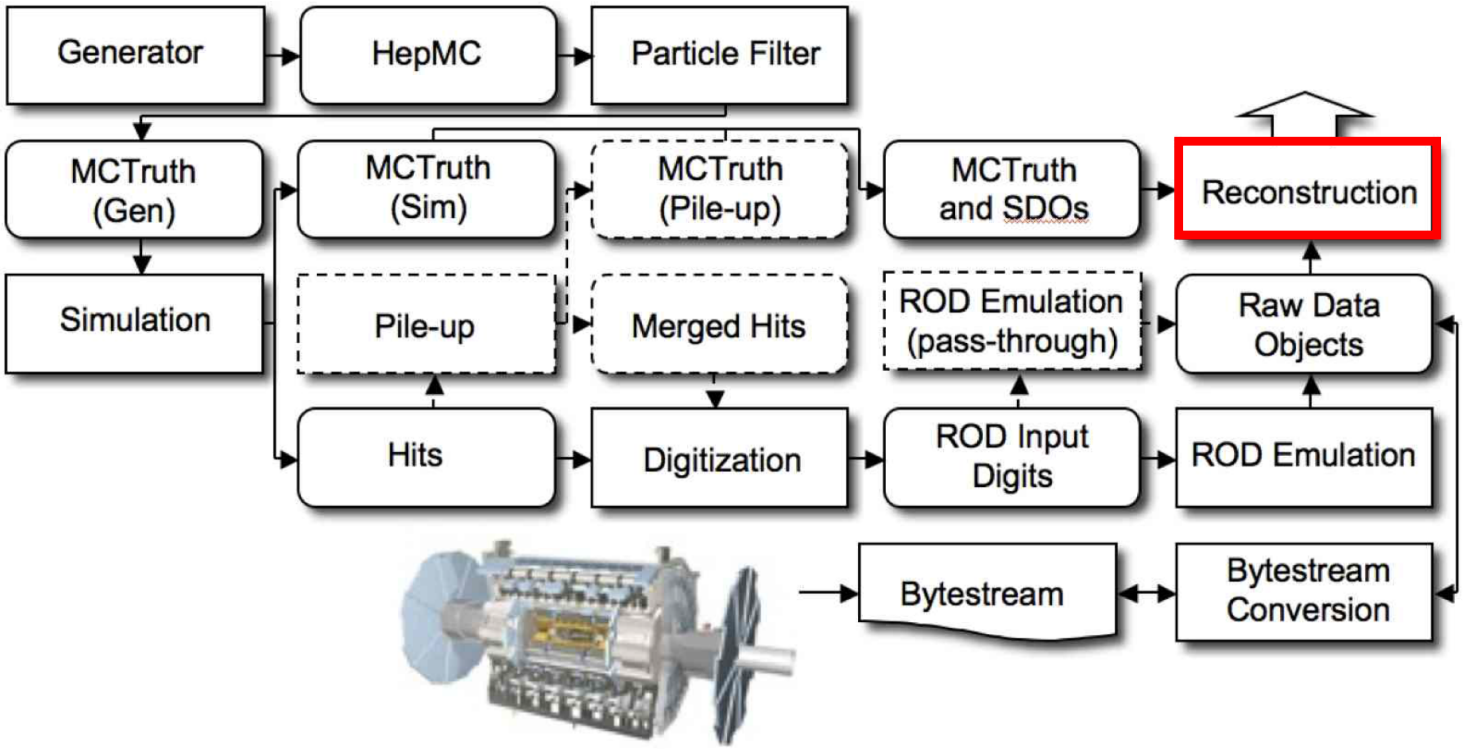



3 main steps in data analysis:

GENERATION → SIMULATION

# Monte Carlo simulation in "brief"

MC simulation is essential in High Energy Physics to understand such processes




3 main steps in data analysis:

GENERATION → SIMULATION → RECONSTRUCTION

# Our MC simulators

LHC use MC simulation based on different models

# Our MC simulators

LHC use MC simulation based on different models

Here we compare b jets pT events from two MC generators:
Alpgen & Sherpa

# Our MC simulators

LHC use MC simulation based on different models

Here we compare b jets pT events from two MC generators:
Alpgen & Sherpa

| **Alpgen+Pythia** | **Sherpa** |
|---|---|
| **General Settings** | |
| • 5 parton LO + multileg matching<br>• 4 flavors scheme | • 4-5 partons LO + 2 parton NLO<br>• 5 flavors scheme |
| **Generator level (Truth level) cuts used during ATLAS sample production** | |
| • 20GeV threshold on Truth pT b-jets<br>• At least 2 b partons | • 5GeV threshold on Truth pT b-jets<br>• At least 1 b hadron |

# Treatment

**My project:** Comparing b-jet yield and pT from Alpgen and Sherpa MC events to check whether they agree with each other

# Treatment

**My project:** Comparing b-jet yield and pT from Alpgen and Sherpa MC events to check whether they agree with each other

**However!**

- Different input at Truth level ➔ producing different results on Reconstructed events (Reco level)
- Need search of a phase space where Alpgen and Sherpa are comparable

# Treatment

**My project:** Comparing b-jet yield and pT from Alpgen and Sherpa MC events to check whether they agree with each other

**However!**

- Different input at Truth level ➔ producing different results on Reconstructed events (Reco level)
- Need search of a phase space where Alpgen and Sherpa are comparable

# Treatment

**My project:** Comparing b-jet yield and pT from Alpgen and Sherpa MC events to check whether they agree with each other

**However!**

- Different input at Truth level ➔ producing different results on Reconstructed events (Reco level)
- Need search of a phase space where Alpgen and Sherpa are comparable


**How?**

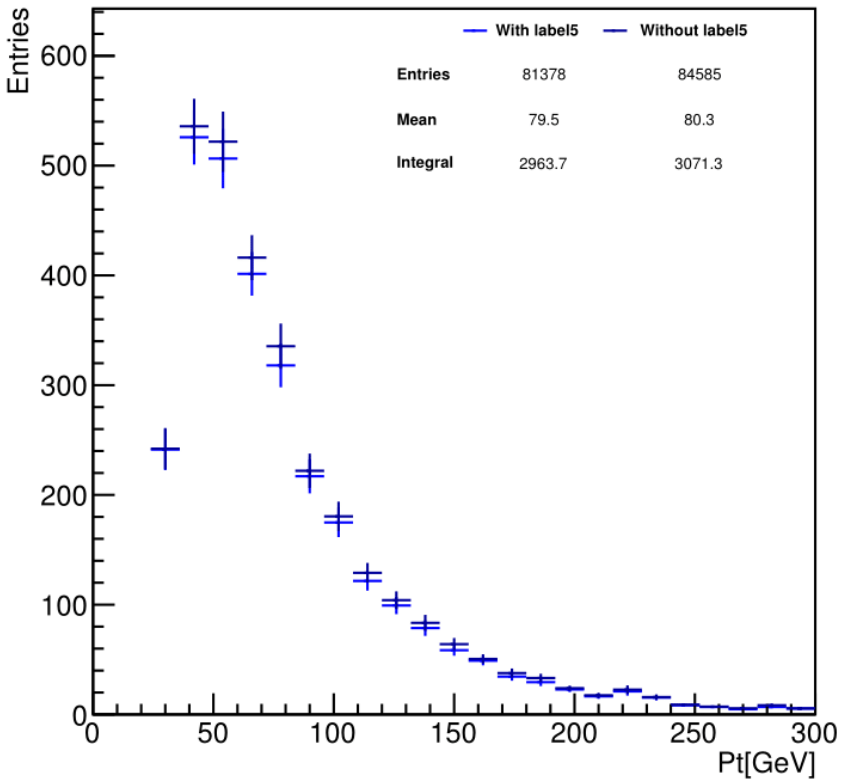
- Imposing b flavor filter ➔ Make sure the outcome will give b jets only!
- Applying rising offline threshold at jet pT=25/30/40GeV + bTagging selection *[bTagging: algorithm for b-jet identification at recon level]*
- Looking for differences between truth and recon simulated events

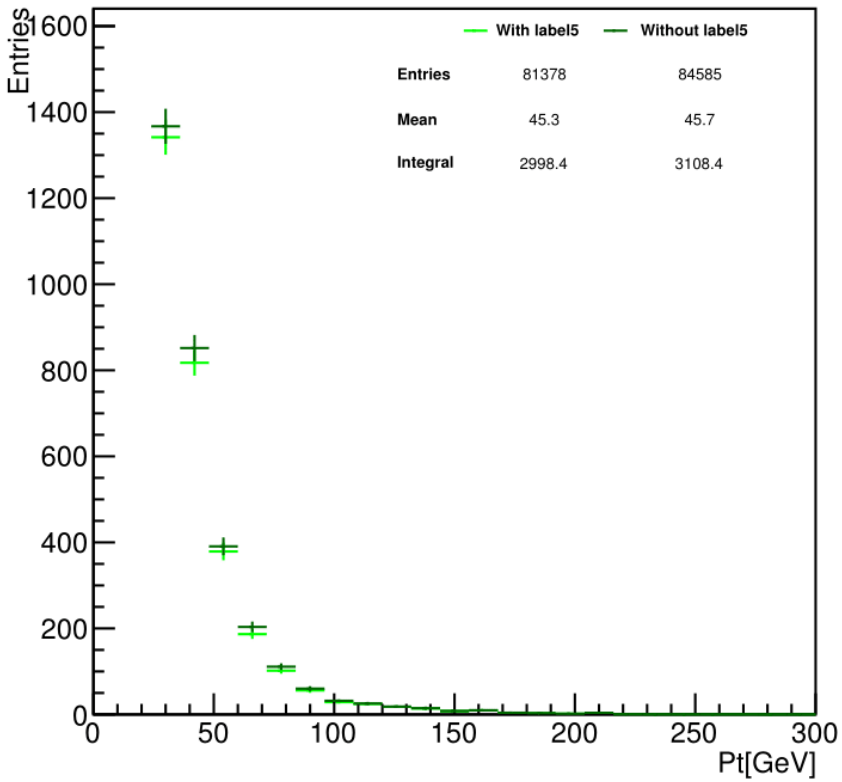
# B-flavor filter at 25GeV [Sherpa WnumuB]

➔ Testing purity of the 2-bTagged sample in the $>0$ b-hadron filtered sample: w/ and w/o truth b-flavour quark matching jet

# B-flavor filter at 25GeV [Sherpa WnumuB]

➔ Testing purity of the 2-bTagged sample in the >0 b-hadron filtered sample: w/ and w/o truth b-flavour quark matching jet



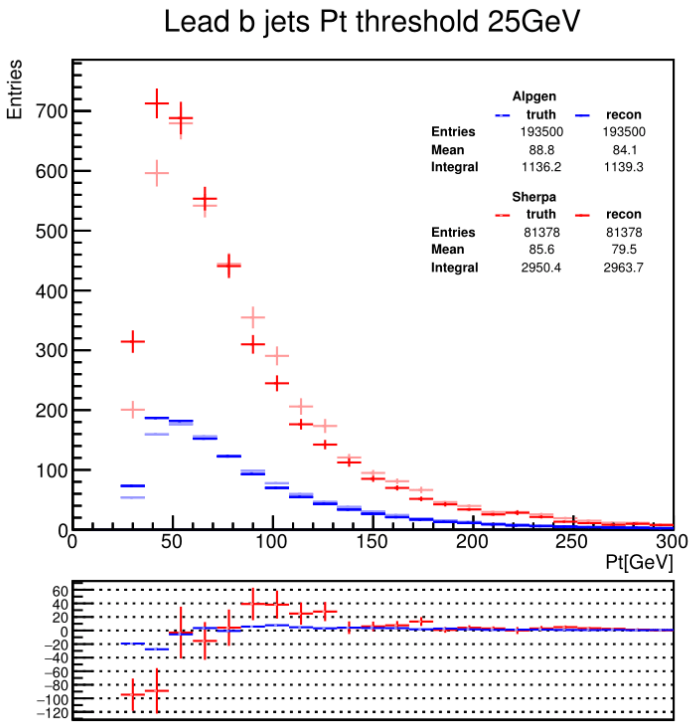

- We observe a contamination of about 6% from events with one of the two jets not matched to a b-quark

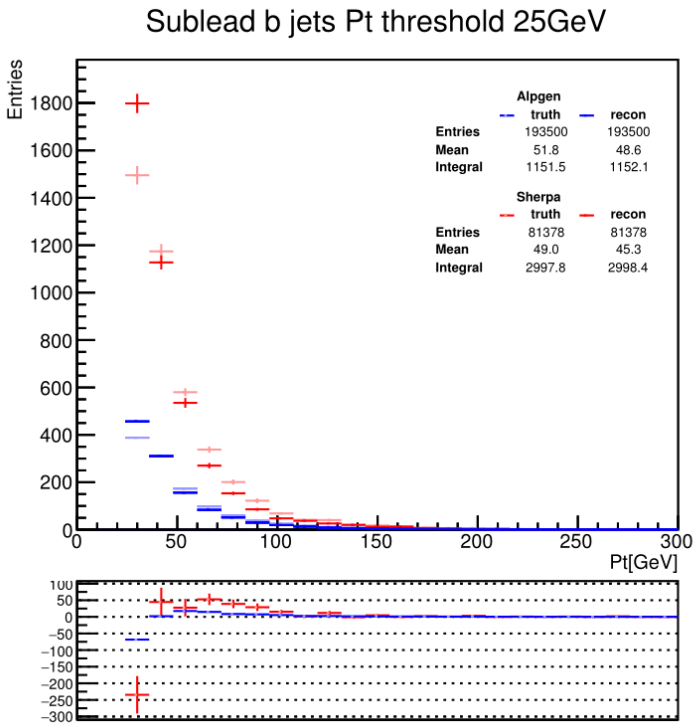
# Offline cuts [25GeV]

➔ Impose the requirement of 2 bTagged jets with 2 b quarks

# Offline cuts [25GeV]

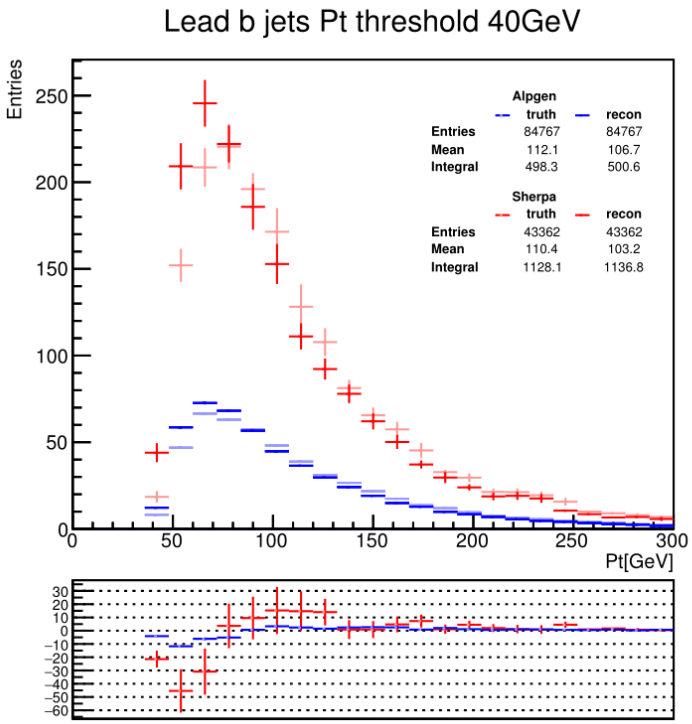
➔ Impose the requirement of 2 bTagged jets with 2 b quarks

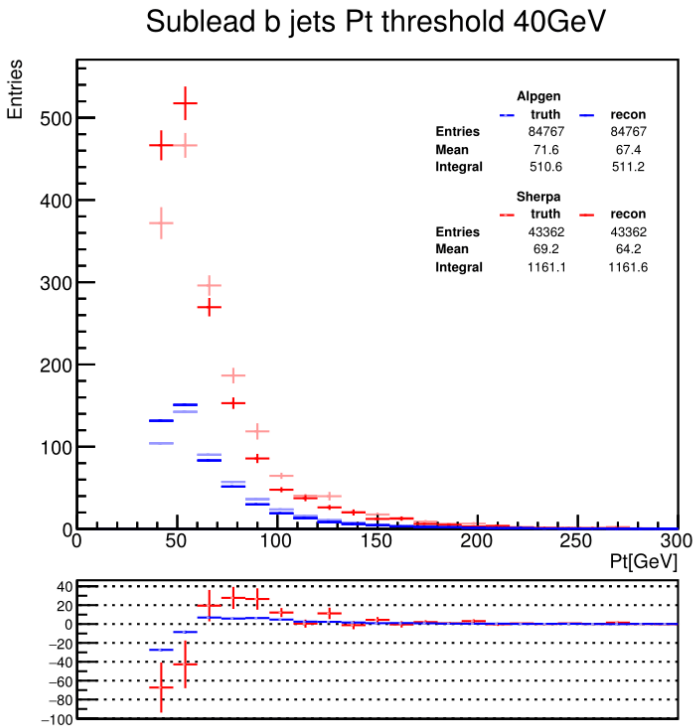



- Predicted yield of 2-btagged events with 2 b-quarks in the final state 38% higher by Sherpa than Alpgen
- $\Delta$ between truth and recon jets is $<0$ for pT$<$60GeV, while $>0$ for pT$>$80GeV ➔ different response to b-jet energy?

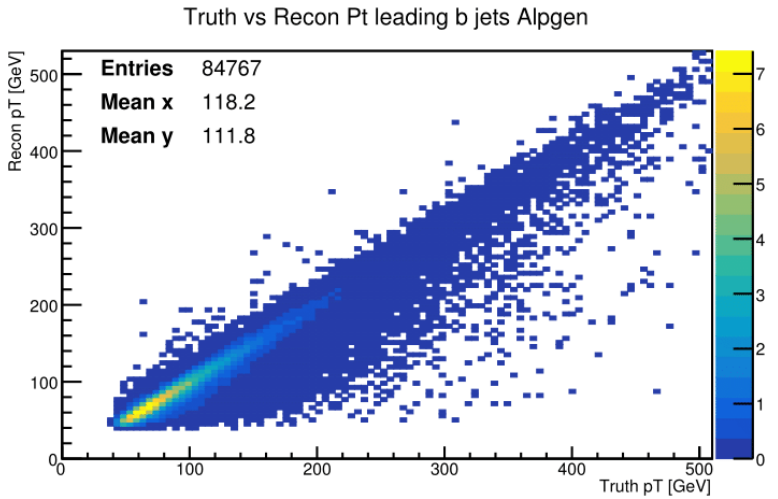
# Offline cuts [40GeV]

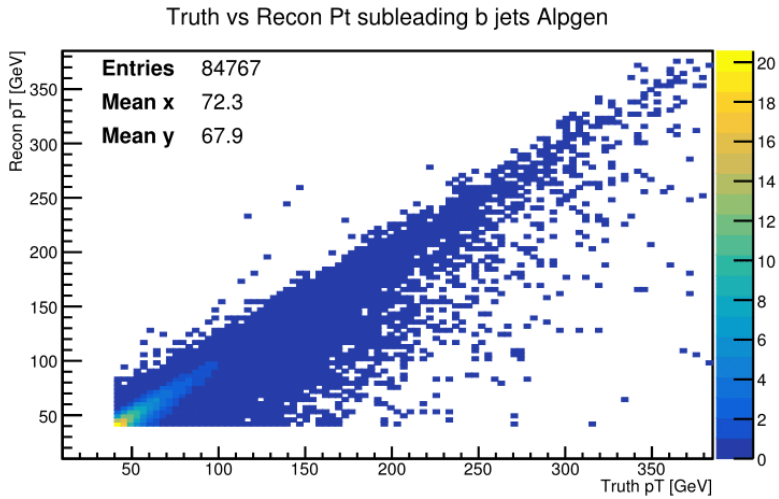


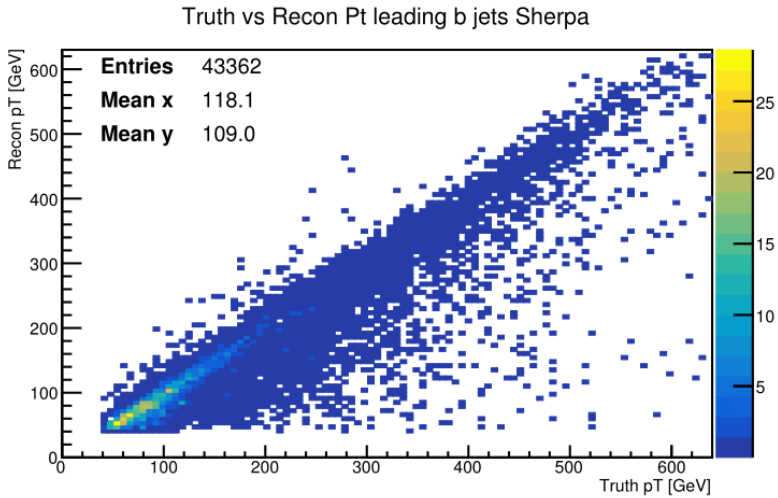



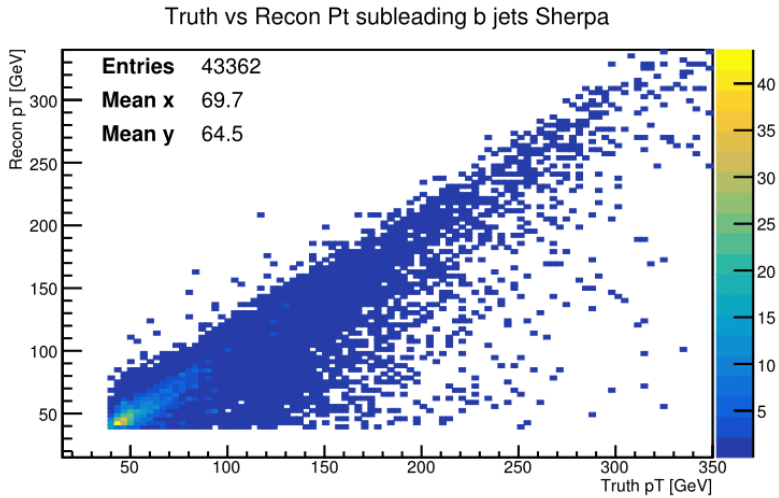

- Predicted yield of 2-btagged events with 2 b-quarks in the final state 44% higher by Sherpa than Alpgen
- 20 GeV away from b-quark generation threshold on Alpgen sample
- Sherpa statistical uncertainty in hist seems large ➔ dominated by MC weights?

# Truth-to-recon b-jet pT migration matrices at 40GeV




- Overall truth to recon migration matrices look linear, however still lot of overflow

# Conclusion

**To sum up**

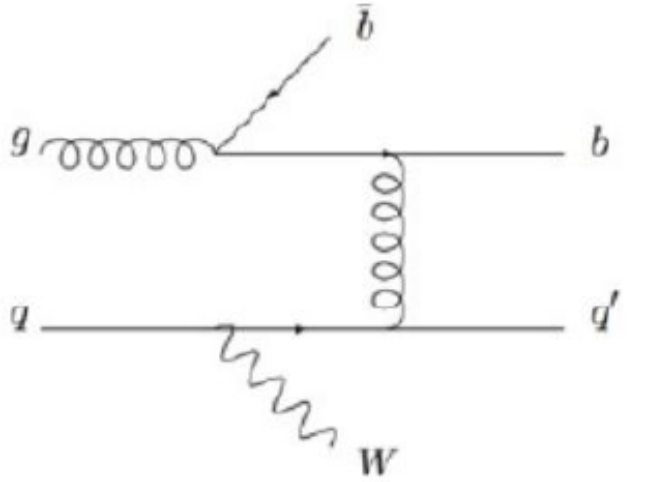
- Preliminary study of purity for 2-bTagged events in Sherpa WmunuB sample: 6% contamination from non btagged jets at low pT cut
- Sherpa and Alpgen predictions for W+bb have been compared in an offline selected region where they should be comparable: 2-bTagged jets with pT>40 GeV
- Still relevant statistical differences at level of circa 50% are present in predicted yield by Sherpa and Alpgen

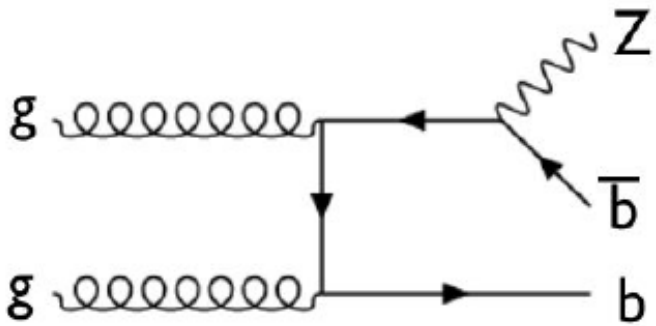
**What's next?**

With the time remaining, enhance the phase of space between the two generators (ex: improve Sherpa's weight treatment)

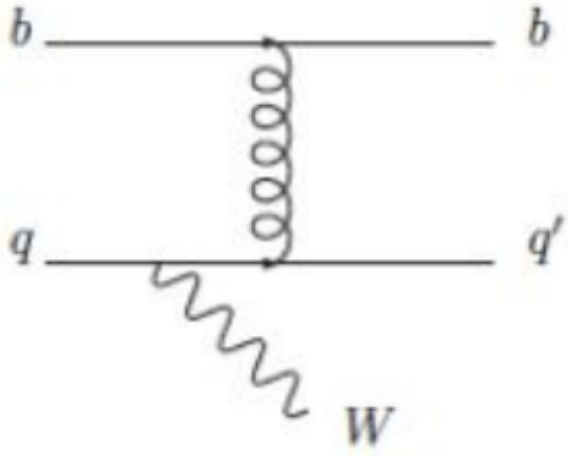
# Explanatory diagrams of 4 and 5 flavors scheme

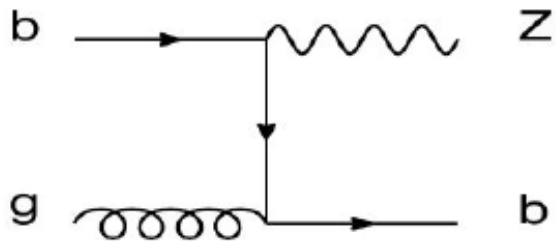
4F diagrams:



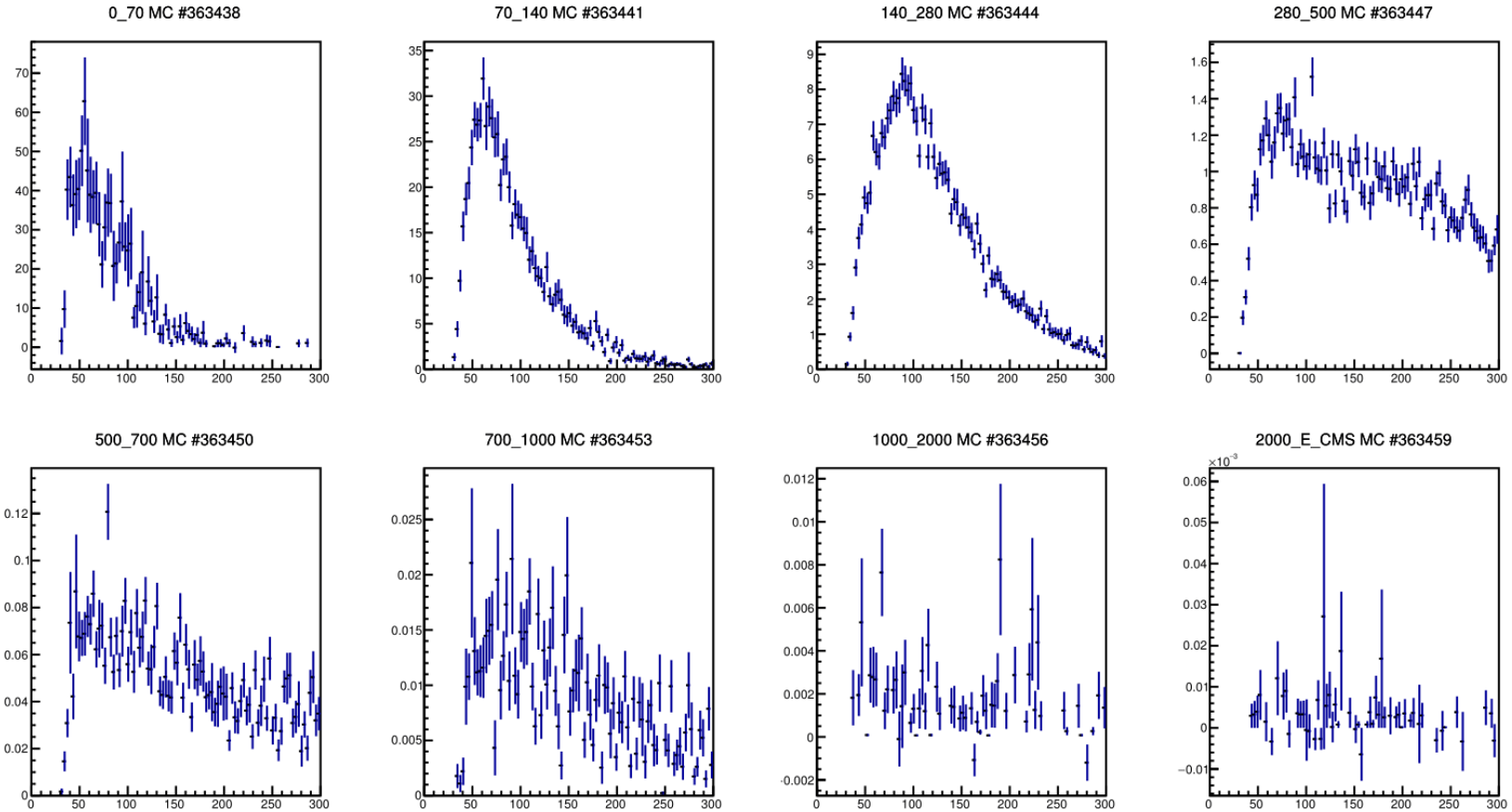

5F diagrams:



# Correcting Sherpa's uncertainties

Study the W pT samples to figure out which one induce high uncertainty to Sherpa data




It appears the first pT bin is the reason here...

# pT bin and associated integrals and their errors

| MC ID# | Integral | Error |
|---|---|---|
| 363438 | 1022.45 | 46.4357 |
| 363441 | 755.748 | 11.0948 |
| 363444 | 334.648 | 2.78262 |
| 363447 | 97.904 | 0.804303 |
| 363450 | 7.60346 | 0.107855 |
| 363453 | 1.37834 | 0.0327578 |
| 363456 | 0.179495 | 0.013415 |
| 363459 | 2.52882e-04 | 5.45692e-05 |