

# Re-Weighting in MG5\_aMC : Discussion

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## Reweighting are everywhere

- scale and pdf uncertainties (available both for LO and NLO computation)
- re-introduce top mass effect for Higgs processes
  - ➔ Higgs production [1110.1728]
  - ➔ Higgs pair mechanism [1401.7340]
  - ➔ ZH associated production [1503.01656]
  - ➔ See talk of Yesterday.
- parameter scan (for coupling/lorentz)

Lagrangian

matrix-element

parton events

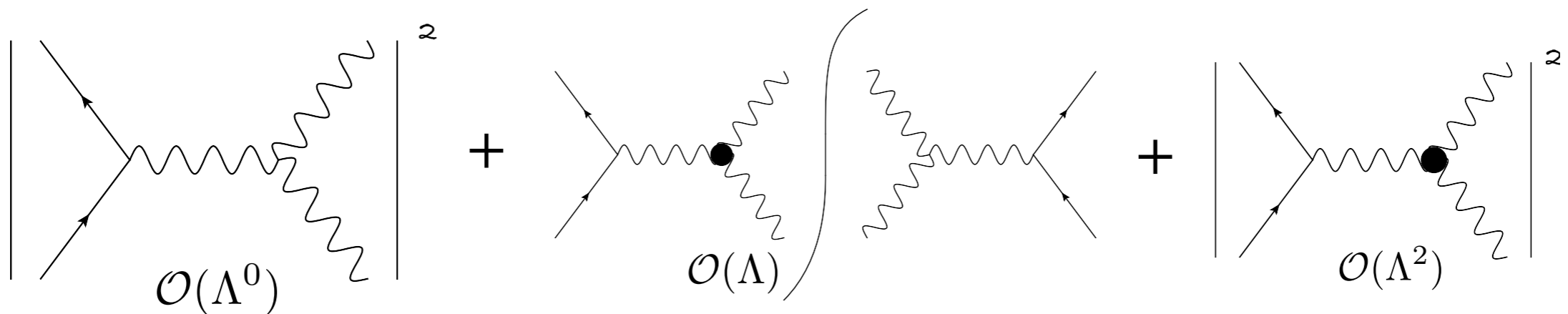
Showered events

hadronized events

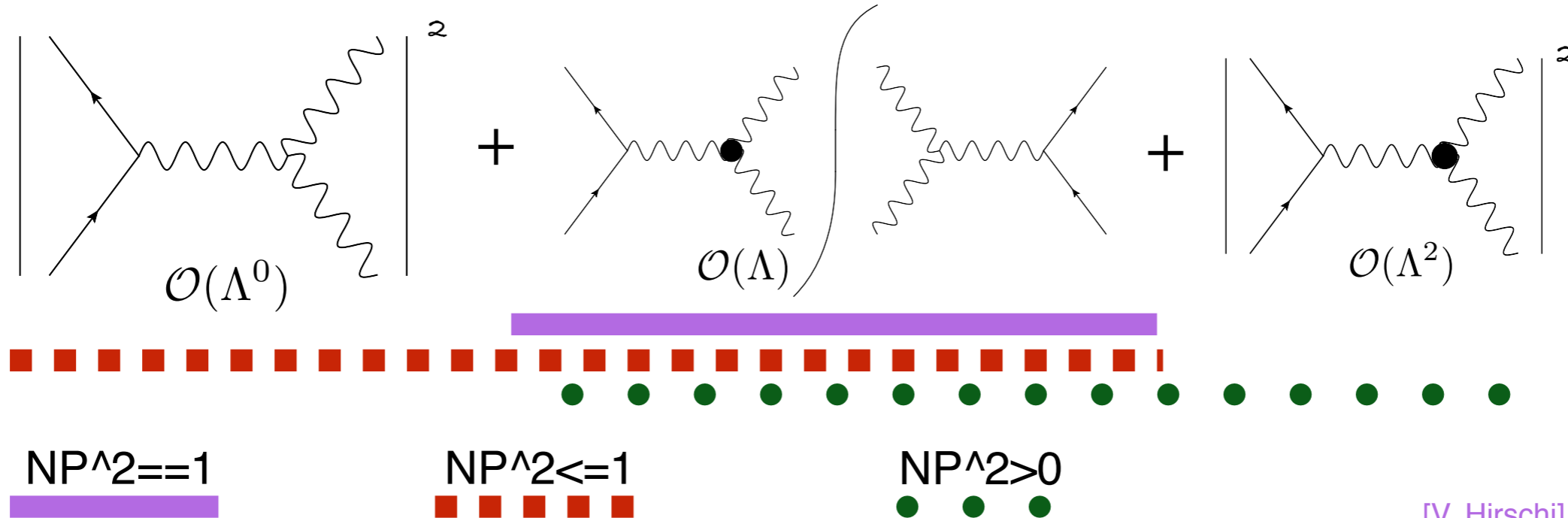
Detector events

**FULL SIMULATION**  
**SLOWEST PART**

- Critical when interference are relevant



## Interference alone



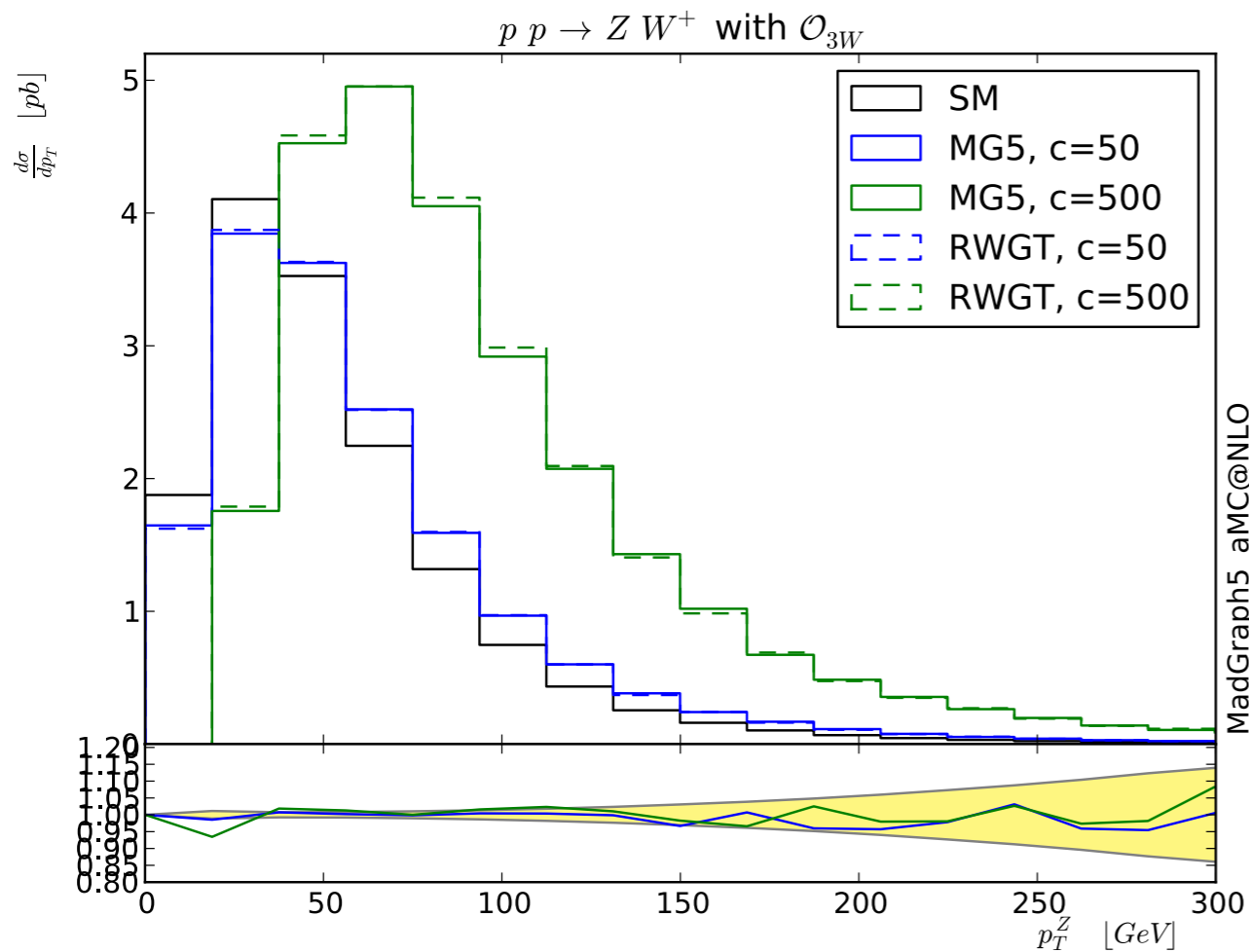
## Re-Weighting

- Reuse the sample (Only one Full Sim)
- Change the weight of the events

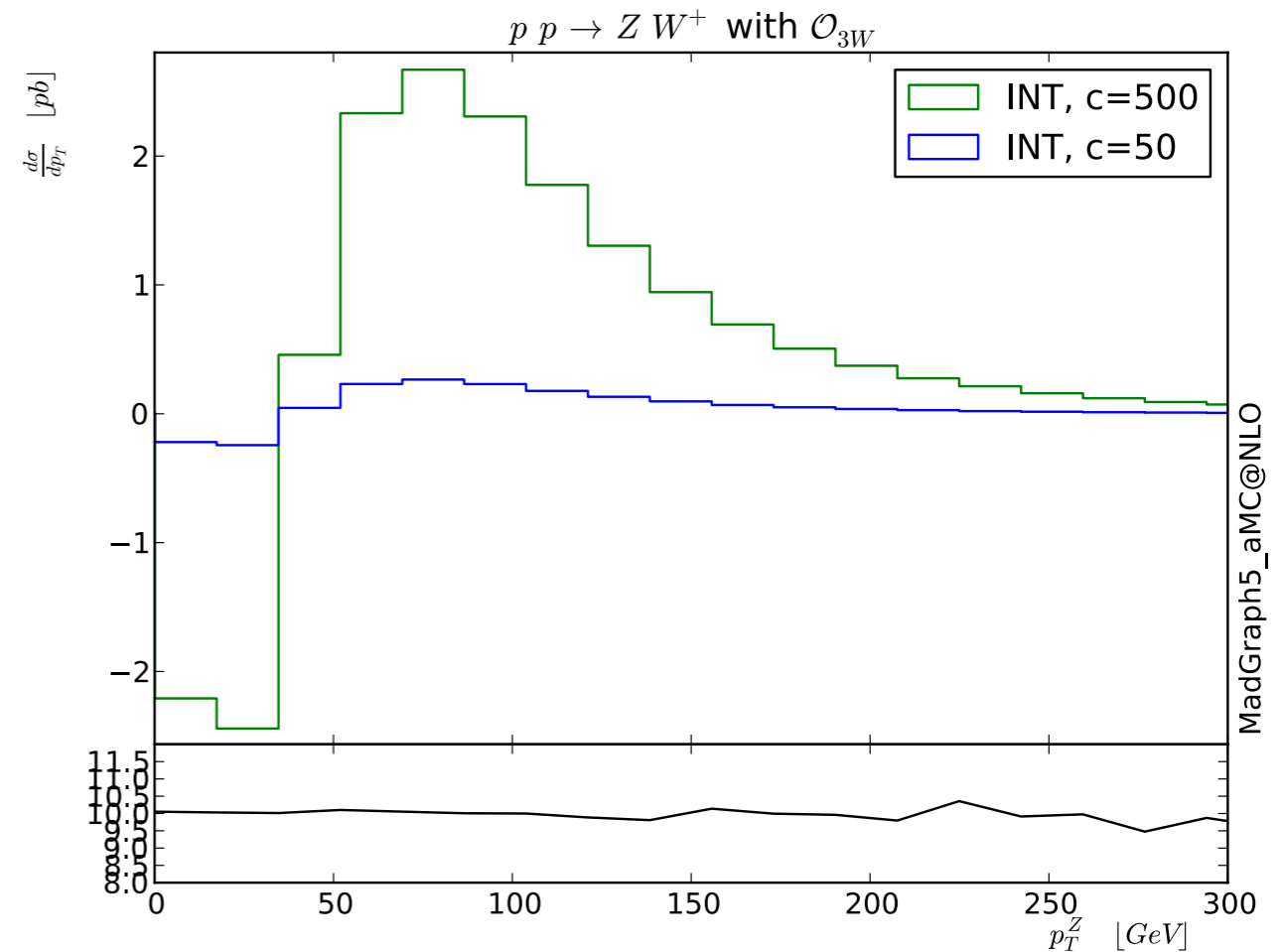
$$W_{new} = \frac{|M_{new}|^2}{|M_{old}|^2} * W_{old}$$

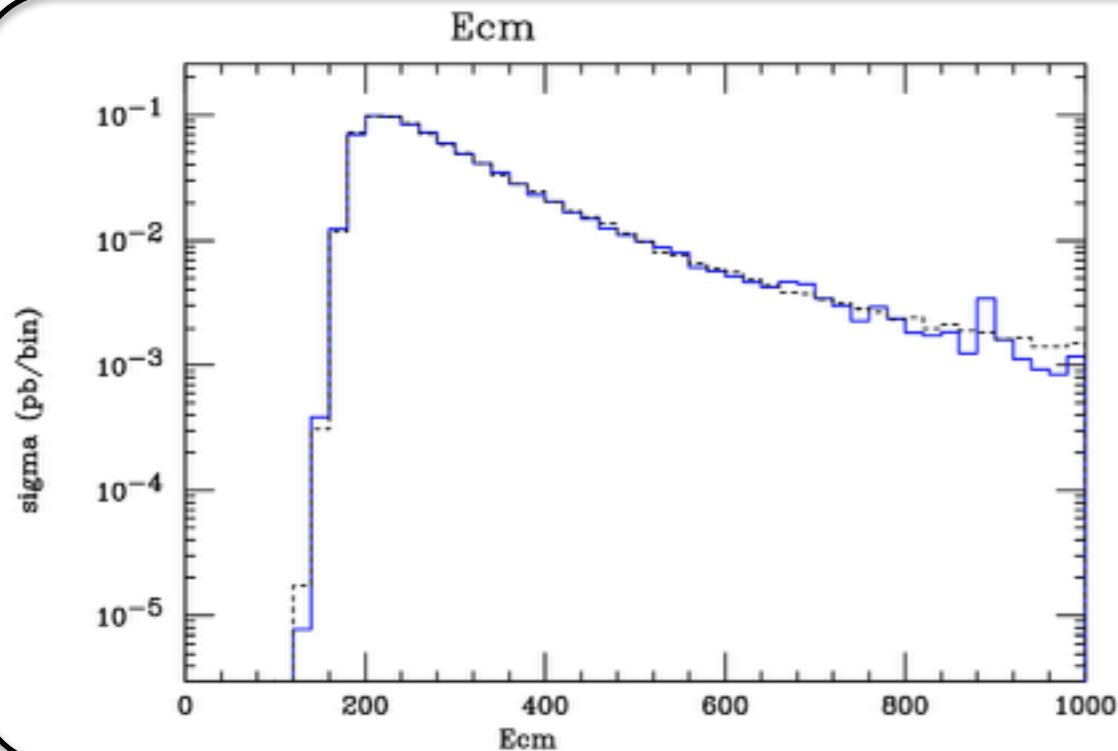
1405.0301  
1404.7129

## Re-Weighting (by SM+Interference)



## Interference contribution





- statistical uncertainty can be enhanced by the re-weighting
- better to have  $wgt < 1$

- You need to have the same phase-space (more exactly a subset)
- Mass scan are possible only in special case
  - only for internal propagator
  - for small mass variation (order of the width)

## LHE Additional information

### Helicity

- Partial helicity distribution are not correct with the full re-weighting

- Solution 
$$W_{new} = \frac{|M_{new}^h|^2}{|M_{orig}^h|^2} W_{orig},$$

In alpha version only

### Leading color information

- modify the shower so not suitable.

### Intermediate particle

- modify the shower so not suitable.

## 1. Generate your (LO) process

- generate
- output

## 2. Run it

- launch

The following switches determine which programs are run:

```
1 Run the pythia shower/hadronization:          pythia=OFF
2 Run PGS as detector simulator:                pgs=OFF
3 Run Delphes as detector simulator:           delphes=NOT INS
4 Decay particles with the MadSpin module:      madspin=OFF
```

```
5 Add weight to events based on coupling parameters: reweight=OFF
```

Either type the switch number (1 to 5) to change its default setting,  
or set any switch explicitly (e.g. type 'madspin=ON' at the prompt)

Type '0', 'auto', 'done' or just press enter when you are done.

```
[0, 1, 2, 4, 5, auto, done, pythia=ON, pythia=OFF, ... ][60s to answer]
```



## 3. Edit the card (reweight\_card.dat)

```
launch
  set Dim6 1 10
  set Dim6 2 0
  set Dim6 3 0
launch
  set Dim6 1 0
  set Dim6 2 10
  set Dim6 3 0
```

4. That's it

## 3. Edit the card (reweight\_card.dat)

launch

set Dim6 1 10

set Dim6 2 0

set Dim6 3 0

launch

set Dim6 1 0

set Dim6 2 10

set Dim6 3 0

Keyword for adding a weight

## 4. That's it

## 3. Edit the card (reweight\_card.dat)

```
launch
```

```
set Dim6 1 10  
set Dim6 2 0  
set Dim6 3 0
```

```
launch
```

```
set Dim6 1 0  
set Dim6 2 10  
set Dim6 3 0
```

Definition of the benchmark

Same syntax as scan over parameter  
set BLOCKNAME ID VALUE

## 4. That's it

## 3. Edit the card (reweight\_card.dat)

launch

```
set Dim6 1 10  
set Dim6 2 0  
set Dim6 3 0
```

launch

```
set Dim6 1 0  
set Dim6 2 10  
set Dim6 3 0
```

Definition of the benchmark

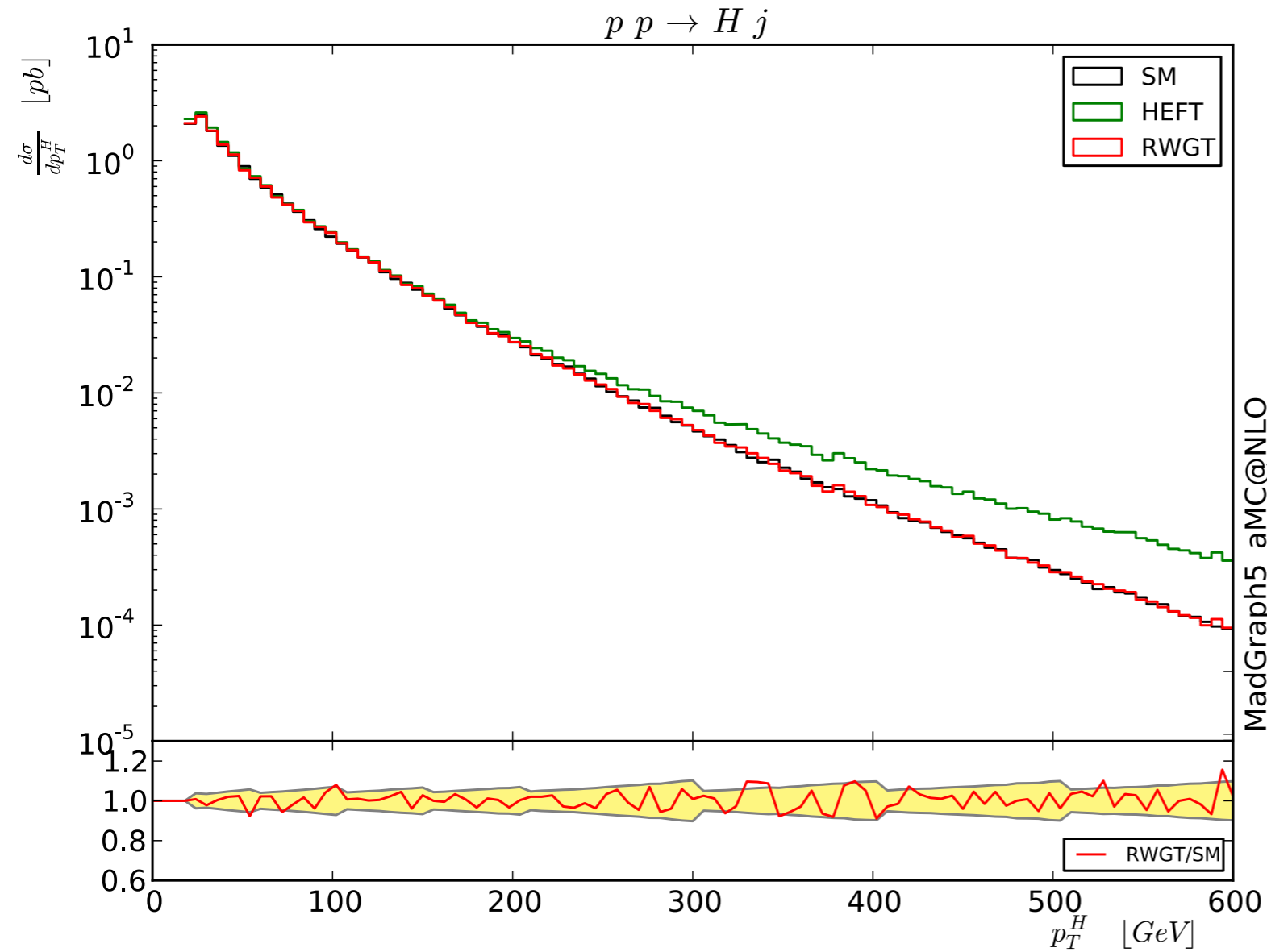
Same syntax as scan over parameter  
set BLOCKNAME ID VALUE

## 4. That's it

**Re-Weighting works as a POSTSCRIPT. You can use Re-Weighting independently of the events generation.**

[Ip:~maddevelo/mg5amcnlo/unleashed\\_reweighting](https://github.com/maddevelo/mg5amcnlo/branches/unleashed_reweighting)

1. Include the re-weighting by a given helicity (as default)
2. Allow to change model
  - ➔ change model NAME
3. Allow to change process
  - ➔ change process XXX [`—add`]
  - ➔ allow loop-induced re-weighting



## proc\_card

```
import model heft
generate p p > h j
output
launch
```

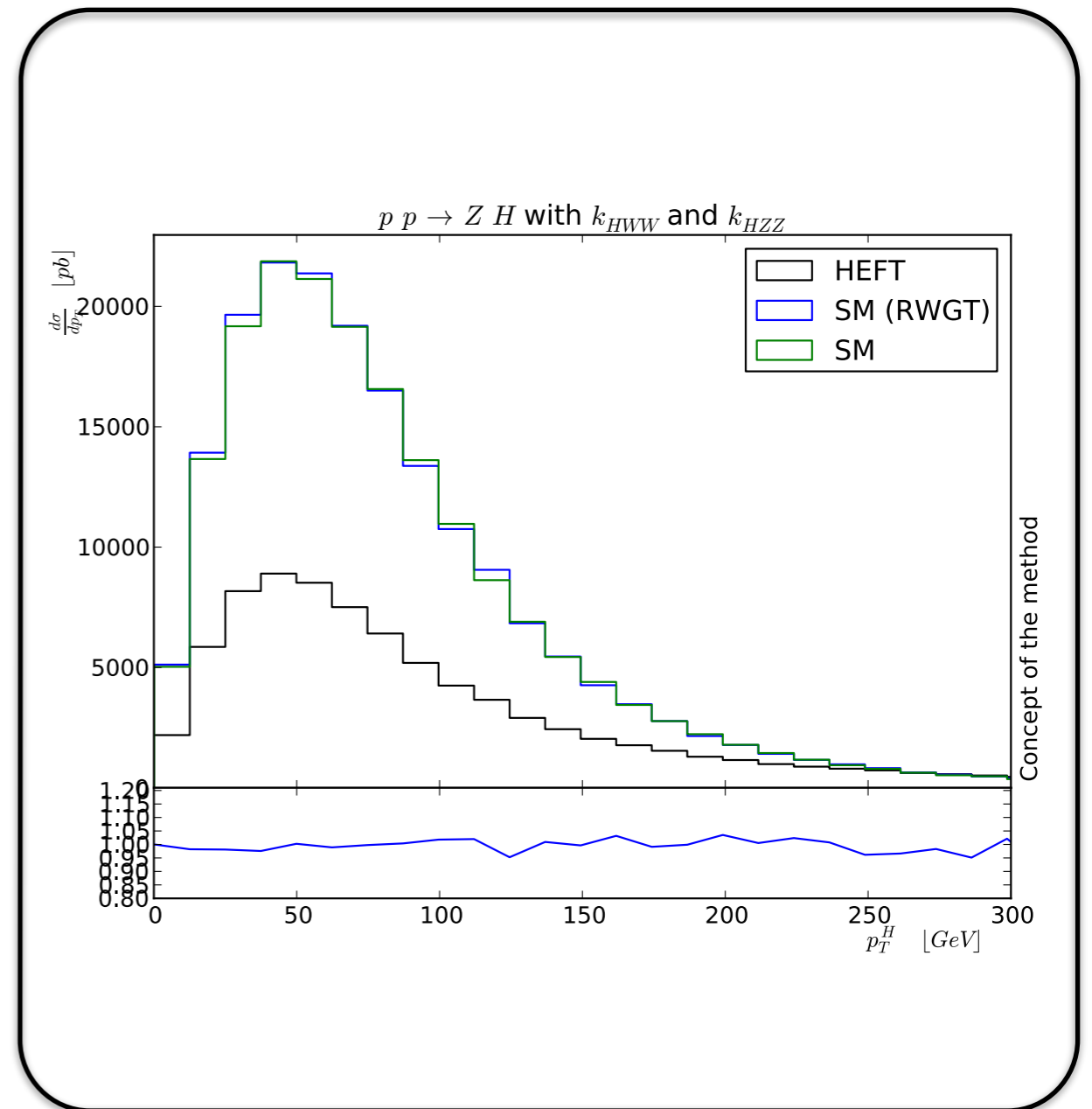
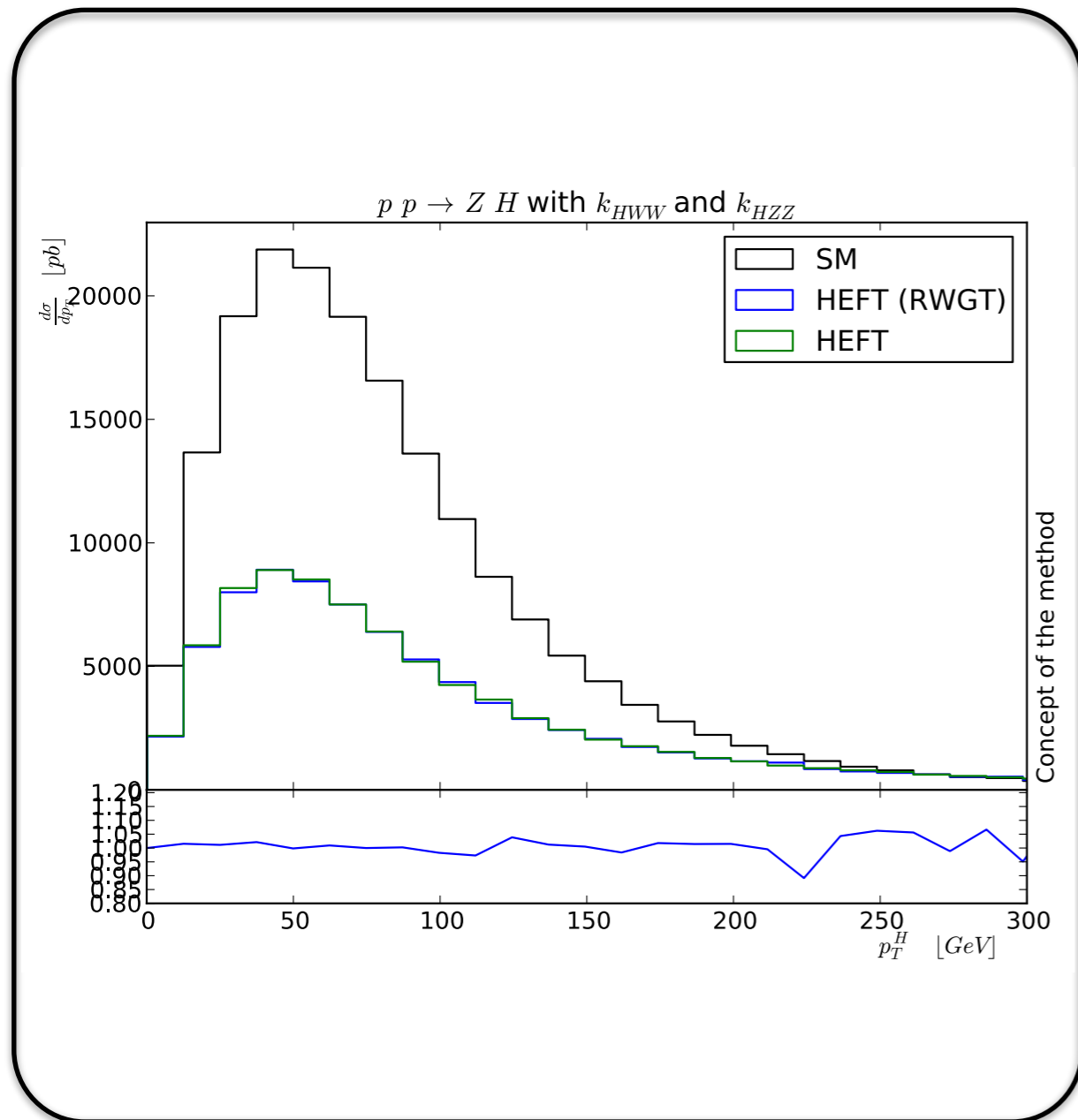
## reweight\_card

```
change model loop_sm
change process g g > H g [sqrvirt=QCD]
change process g u > H u [sqrvirt=QCD] —add
change process g u~ > H u~ [sqrvirt=QCD] —add
change process g d~ > H d~ [sqrvirt=QCD] —add
change process g c > H c [sqrvirt=QCD] —add
change process g c~ > H c~ [sqrvirt=QCD] —add
change process g s > H s [sqrvirt=QCD] —add
change process g s~ > H s~ [sqrvirt=QCD] —add
launch
~/Cards/param_card_loop_sm.dat
```

[Ip:~maddevelopers/mg5amcnlo/unleashed\\_reweighting](https://github.com/maddevelopers/mg5amcnlo/unleashed_reweighting)

1. Include the re-weighting by a given helicity (as default)
2. Allow to change model
  - ➔ change model NAME
3. Allow to change process
  - ➔ change process XXX [—add]
  - ➔ allow loop-induced re-weighting
4. Re-weighting NLO events by LO Matrix-Element (implemented Sunday night not yet tested)

Caution: Plot are for aMC@NLO before shower  
(due to time constraint!). Those are not physical.





- Re-using previous generation/computation is always a smart move.
- Doing it off-line (independently of the event generation)
  - allows to reuse old generation (good)
  - means less efficient (cpu/memory) (bad)
  - is at the end a smart move
- Discussion : Full NLO Re-Weighting
  - offline / online Re-weighting?
  - Is all the information relevant in the internal format? (example: virt-tricks)

## MC@NLO

$$\frac{d\sigma_{\text{NLOwPS}}}{dO} = \left[ d\Phi_m (B + \int_{\text{loop}} V + \int d\Phi_1 MC) \right] I_{\text{MC}}^{(m)}(O) \\ + \left[ d\Phi_{m+1} (R - MC) \right] I_{\text{MC}}^{(m+1)}(O)$$

## LHE

- “S-events” (which have m body kinematics)
- “H-events” (which have m+1 body kinematics)

## Re-Weighting

- “S-events” need to be re-weight by the born/virtual + counter-term
- “H-events” need to be re-weight by the real + counter-term

## Status

- Recent change in the code will make this fully possible

without un-weighting

$$\begin{aligned}\sigma_{orig} &= \sum_{i=1}^N W_{orig}^i \\ &= \sum_{i=1}^N f_1(x_1^i) \cdot f_2(x_2^i) \cdot |M_{orig}^i|^2 \cdot d\Omega\end{aligned}$$

$$\begin{aligned}\sigma_{new} &= \sum_{i=1}^N W_{new}^i \\ &= \sum_{i=1}^N f_1(x_1^i) \cdot f_2(x_2^i) \cdot |M_{new}^i|^2 \cdot d\Omega\end{aligned}$$

without un-weighting

$$\begin{aligned}\sigma_{orig} &= \sum_{i=1}^N W_{orig}^i \\ &= \sum_{i=1}^N f_1(x_1^i) \cdot f_2(x_2^i) \cdot |M_{orig}^i|^2 \cdot d\Omega\end{aligned}$$

$$\begin{aligned}\sigma_{new} &= \sum_{i=1}^N W_{new}^i \\ &= \sum_{i=1}^N f_1(x_1^i) \cdot f_2(x_2^i) \cdot |M_{new}^i|^2 \cdot d\Omega \\ &= \sum_{i=1}^N W_{orig}^i \cdot \frac{|M_{new}^i|^2}{|M_{orig}^i|^2}\end{aligned}$$

## unweighted sample

$$\begin{aligned}
 \sigma_{orig} &= \sum_{i=1}^N W_{orig}^i, \\
 &= \max_i(W_{orig}^i) \sum_{i=1}^N \frac{W_{orig}^i}{\max_i(W_{orig}^i)}, \\
 &\approx \sum_{i=1}^N \max_i(W_{orig}^i) Acc_i
 \end{aligned}$$

$$\begin{aligned}
 \sigma_{new} &= \sum_{i=1}^N W_{new}^i, \\
 &= \max_i(W_{orig}^i) \sum_{i=1}^N \frac{W_{new}^i}{\max_i(W_{orig}^i)}, \\
 &= \max_i(W_{orig}^i) \sum_{i=1}^N \frac{W_{new}^i}{W_{orig}^i} \frac{W_{orig}^i}{\max_i(W_{orig}^i)}, \\
 &\approx \sum_{i=1}^N \max_i(W_{orig}^i) Acc_i \cdot \frac{|M_{new}|^2}{|M_{orig}|^2}
 \end{aligned}$$

$$\begin{aligned}\sigma_{orig} &= \sum_{i=1}^N W_{orig}^i P_{h,orig}^i \\ &= \sum_{i=1}^N W_{orig}^i \frac{|M_{orig}^h|^2}{\sum_{\tilde{h}} |M_{orig}^{\tilde{h}}|^2},\end{aligned}$$

$$\begin{aligned}\sigma_{new} &= \sum_{i=1}^N W_{new}^i P_{h,new}^i \\ &= \sum_{i=1}^N W_{new}^i \frac{|M_{new}^h|^2}{\sum_{\tilde{h}} |M_{new}^{\tilde{h}}|^2}, \\ &= \sum_{i=1}^N W_{orig}^i \frac{\sum_{\tilde{h}} |M_{new}^{\tilde{h}}|^2}{\sum_{h'} |M_{orig}^{h'}|^2} \frac{|M_{new}^h|^2}{\sum_{\tilde{h}} |M_{new}^{\tilde{h}}|^2}, \\ &= \sum_{i=1}^N W_{orig}^i \frac{1}{\sum_{h'} |M_{orig}^{h'}|^2} \frac{|M_{new}^h|^2}{1}, \\ &= \sum_{i=1}^N W_{orig}^i \frac{|M_{orig}^h|^2}{\sum_{h'} |M_{orig}^{h'}|^2} \frac{|M_{new}^h|^2}{|M_{orig}^h|^2}, \\ &= \sum_{i=1}^N W_{orig}^i P_{h,orig}^i \frac{|M_{new}^h|^2}{|M_{orig}^h|^2}.\end{aligned}$$