

# TUTORIAL ON MADGRAPH5\_AMC@NLO:

## FROM UFO MODEL TO SIGNALS AND BACKGROUND

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# EXERCISES: SIGNALS



- Let us start with a new UFO model you generated on Monday. Let us call it **MyDMMModel**. Put it in **/MG5aMC/PATH/models** and load the model via

```
> import model MyDMMModel
```

- If you do not success to generate a working one, you can download the existing model via

```
> import model DMsimp_s_spin1
```

- Generate events for the monojet (jet+missing energy) signal with 3 different dark matter ( $\chi$ ,  $\chi$ ) masses

```
> generate p p >  $\chi$   $\chi$  j
```

➡ Try to use another way instead of the interactive interface

- **Hint I:** Use e.g. '**set MXd = 50**' command to edit **param\_card.dat** (similar for **run\_card.dat**)
- **Hint II:** All interactive commands (including answers) can be put in a file. E.g. run '**./bin/mg5\_aMC <PATH\_TO\_COMMAND\_FILE>**'

# EXERCISES: SIGNALS



- Change the value of mediator (YI, PDG is 55) width
  - **Hint:** Use e.g. 'set width 55 auto' command to edit `param_card.dat`
  - Check the width value is correct.
- Check the cuts imposed in `run_card.dat` and think whether the cuts can be released (infrared safe ?).

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- Scan the parameters. Do it with `MXd=10,50,100,300` (remember to 'set width 55 auto' or 'set WYI auto').

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```
Do you want to edit a card (press enter to bypass editing)?
/-----/
| #1. param the top mass      : param_card.dat
| #2. run the top width      : run_card.dat
| #3. madanalysis5_parton    : madanalysis5_parton_card.dat
|-----|
Do you want to edit a card (press enter to bypass editing)?
/-----/
| #1. param the top mass      : param_card.dat
| #2. run the top width      : run_card.dat
| #3. madanalysis5_parton    : madanalysis5_parton_card.dat
|-----|
you can also
to # changing the top mass
- enter the path to a valid card or banner.
- use the 'set' command to modify a parameter directly.
  The set option works only for param_card and run_card.
  Type 'help set' for more information on this command.
- call an external program (ASperGE/MadWidth/...).
  Type 'help' for the list of available command
[0, done, 1, param, 2, run, 3, madanalysis5_parton, enter path][90s to answer]
>set MXd scan:[10,50,100,300]
```

# EXERCISES: SIGNALS



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```
Do you want to edit a card (press enter to bypass editing)?
/-----/
| #1. param the top mass      : param_card.dat |
| #2. run the top width      : run_card.dat    |
| #3. madanalysis5_parton    : madanalysis5_parton_card.dat |
|-----|
0 # changing the top mass
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  Type 'help set' for more information on this command.
- call an external program (ASperGE/MadWidth/...).
  Type 'help' for the list of available command
[0. done, 1. param, 2. run, 3. madanalysis5_parton, enter path]
>set WYI auto
```

- Change the value of n
- Hint: Use e.g. 'set width 55
- Check the width value
- Check the cuts impos
- the cuts can be releas



# EXERCISES: SIGNALS



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Results in the `DMsimp_s_spin1` for  $p p > x d x d \sim j$

Run	Collider	Banner	Cross section (pb)	Events	Data	Output	Action
run_01	$p p$ 6500.0 x 6500.0 GeV	<a href="#">tag_1</a>	<a href="#">5.523 ± 0.012</a>	10000	parton madevent	<a href="#">LHE MA5_report_analysis1</a>	<button>remove run</button> <button>launch detector simulation</button>
run_02	$p p$ 6500.0 x 6500.0 GeV	<a href="#">tag_1</a>	<a href="#">5.503 ± 0.014</a>	10000	parton madevent	<a href="#">LHE MA5_report_analysis1</a>	<button>remove run</button> <button>launch detector simulation</button>
run_03	$p p$ 6500.0 x 6500.0 GeV	<a href="#">tag_1</a>	<a href="#">5.458 ± 0.017</a>	10000	parton madevent	<a href="#">LHE MA5_report_analysis1</a>	<button>remove run</button> <button>launch detector simulation</button>
run_04	$p p$ 6500.0 x 6500.0 GeV	<a href="#">tag_1</a>	<a href="#">5.083 ± 0.016</a>	10000	parton madevent	<a href="#">LHE MA5_report_analysis1</a>	<button>remove run</button> <button>launch detector simulation</button>

# MERGING ME WITH PS

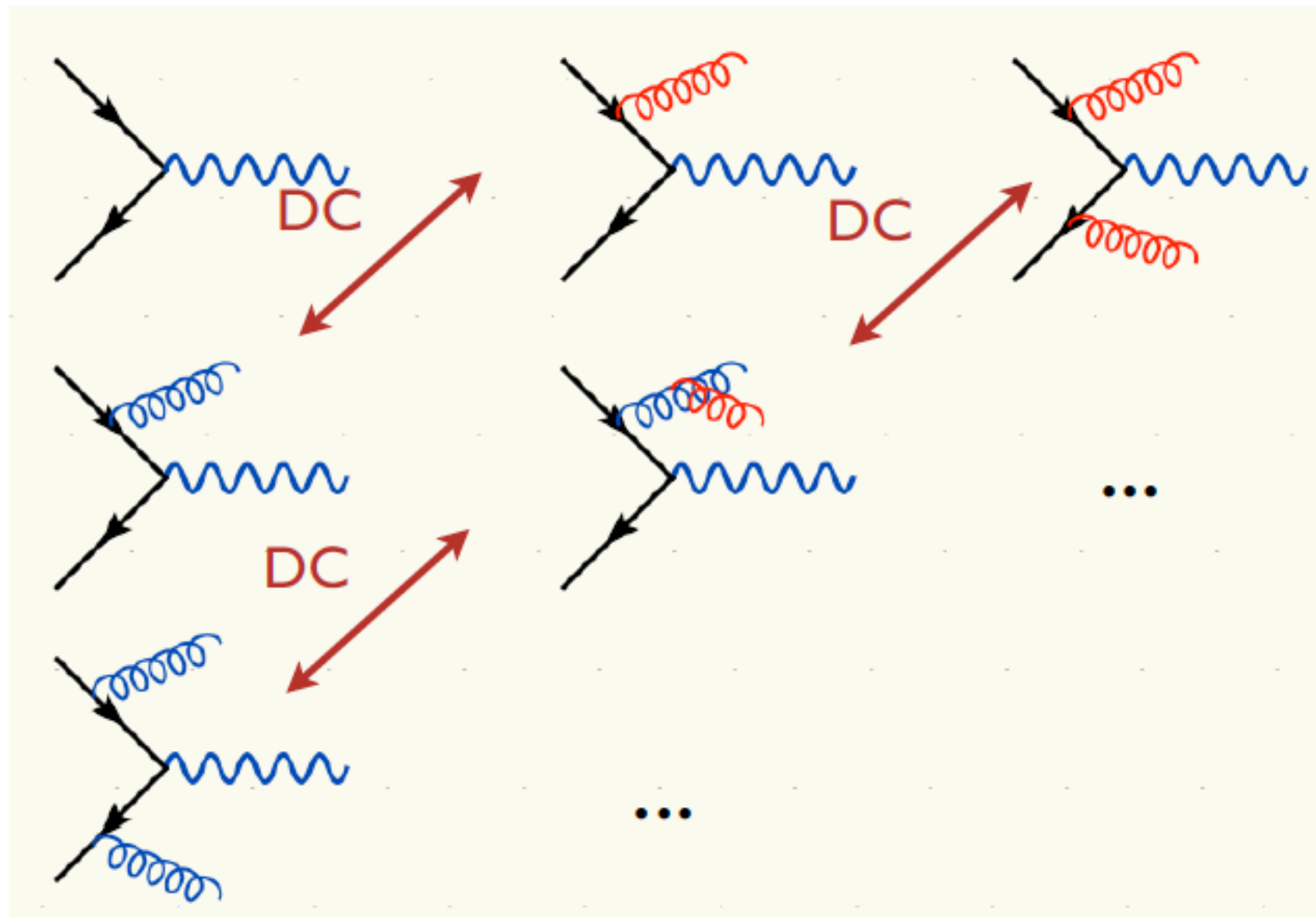
PS →

$$pp \rightarrow X$$

$$pp \rightarrow X + j \text{ ME}$$



$$pp \rightarrow X + jj$$



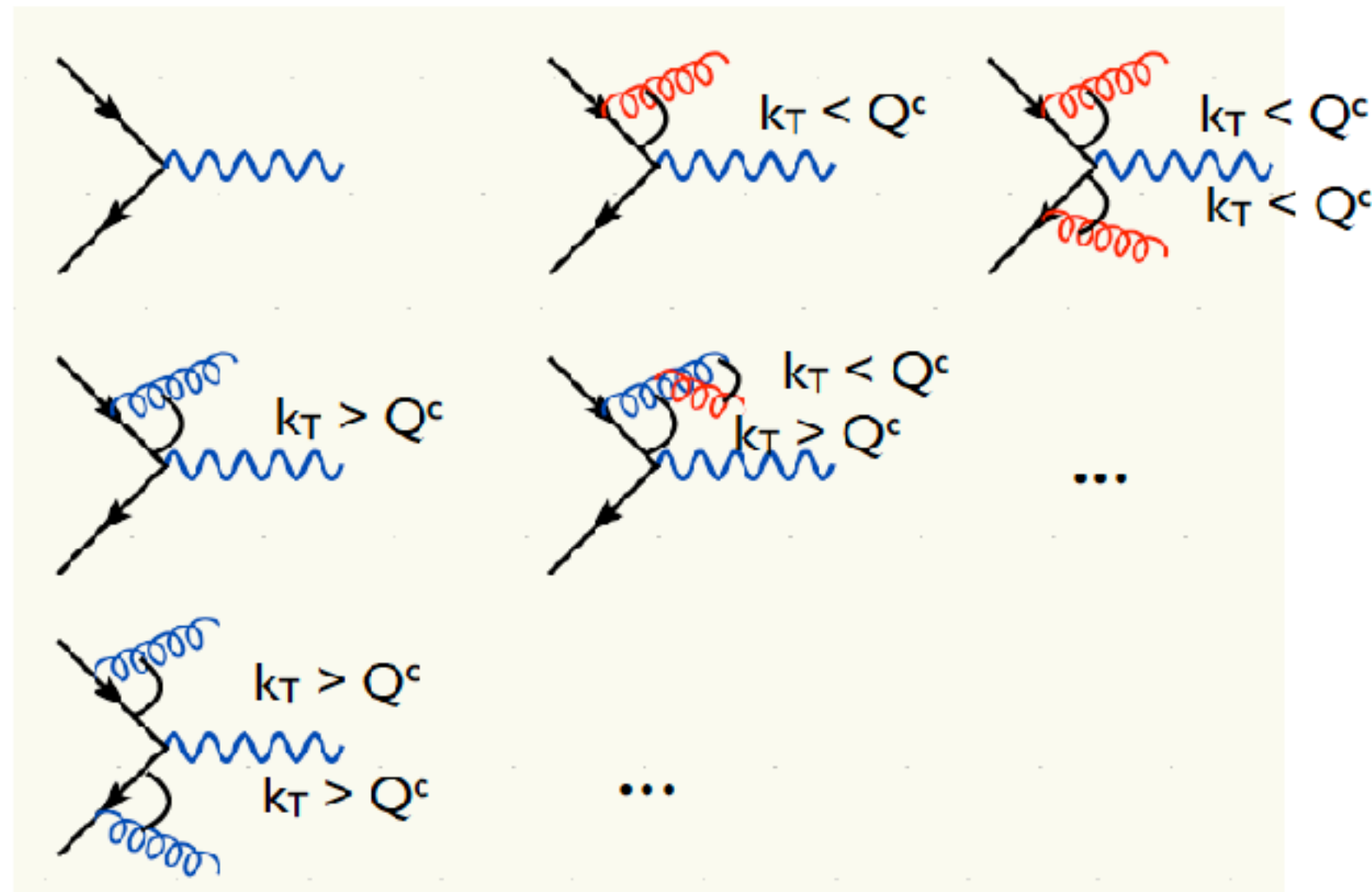


# Merging ME with PS

[Mangano]  
[Catani, Krauss, Kuhn, Webber]

PS  $\rightarrow$

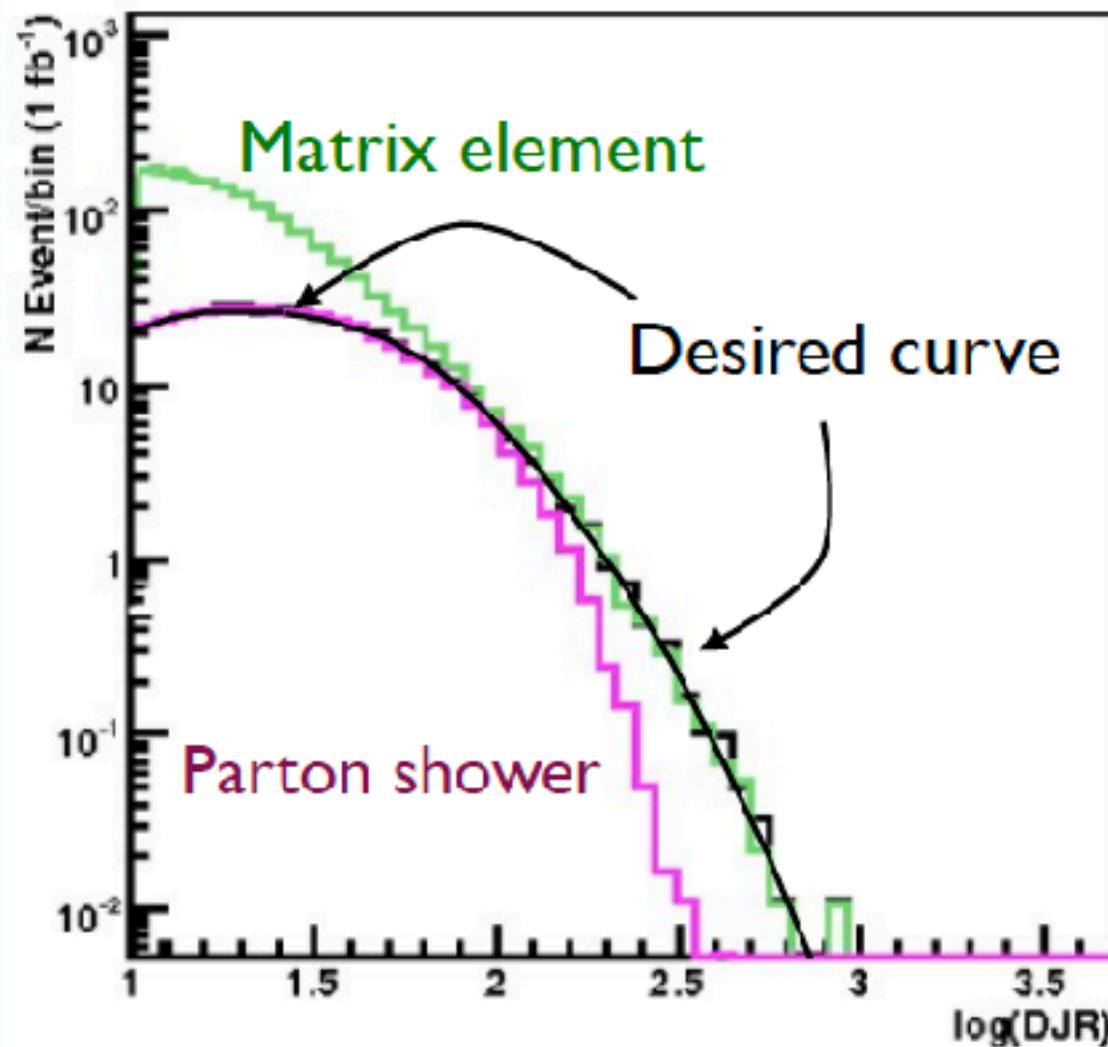
ME  
 $\downarrow$



Double counting between ME and PS easily avoided using phase space cut between the two: PS below cutoff, ME above cutoff.

# MERGING ME WITH PS

- Regularization of matrix element divergence
- Correction of the parton shower for large momenta
- Smooth jet distributions



2nd QCD radiation jet in  
top pair production at  
the LHC, using  
MadGraph + Pythia

# MERGING ME WITH PS



1. Generate ME events (with different parton multiplicities) using parton-level cuts ( $p_T^{\text{ME}}/\Delta R$  or  $k_T^{\text{ME}}$ )
2. Cluster each event and reweight  $\alpha_s$  and PDFs based on the scales in the clustering vertices
3. Apply Sudakov factors to account for the required non-radiation above clustering cutoff scale and generate parton shower emissions below clustering cutoff:
  - a. (CKKW) Analytical Sudakovs + truncated showers
  - b. (CKKW-L) Sudakovs from truncated showers
  - c. (MLM) Sudakovs from reclustered shower emissions

# EXERCISES: LO MERGING



- Multiply jet merging for signals (pythia8 installed)

```
./bin/mg5_aMC
> import model MyDMMModel
> generate p p > xd xd~
> generate p p > xd xd~ j
> add process p p > xd xd~ j j
> output MyMergingExample
> launch
```

- Turn on the shower with pythia8

```
Type '0', 'auto', 'done' or just press enter when you are done.
The following switches determine which programs are run:
/----- Description -----|----- values -----|----- other options -----\
| 1. Choose the shower/hadronization program | shower = Pythia8      | OFF                      | |
| 2. Choose the detector simulation program   | detector = Not Avail. | Please install module   |
| 3. Choose an analysis package (plot/convert)| analysis = MadAnalysis5 | OFF                      |
| 4. Decay onshell particles                  | modspin = OFF         | ON|onshell               |
| 5. Add weights to events for new hypp.      | reweight = OFF        | ON                        |
\-----|-----|-----/

Either type the switch number (1 to 5) to change its setting,
Set any switch explicitly (e.g. type 'shower=OFF' at the prompt)
Type 'help' for the list of all valid option
Type '0', 'auto', 'done' or just press enter when you are done.
|>0
```



# EXERCISES: CKKW-L MERGING

- Edit the `run_card.dat`

```
#####
# Matching parameter (MLM only)
#####
0 = ickkw ! 0 no matching, 1 MLM
1.0 = alpsfact ! scale factor for QCD emission vx
False = cnccluster ! cluster only according to channel diag
5 = asrwtflavor ! highest quark flavor for a_s reweight
False = auto_ptj_mj ! Automatic setting of ptj and mj if xqcut > 0
! (turn off for VBF and single top processes)
0.0 = xqcut
```

Turn off MLM scheme

Set xqcut to be zero

```
#####
# Turn on either the ktdurham or ptlund cut to activate
# CKKW(L) merging with Pythia8 [arXiv:1410.3012, arXiv:1109.4829]
#####
20.0 = ktdurham
0.4 = dparameter
-1.0 = ptlund
1, 2, 3, 4, 5, 6, 21, 82 = pdgs_for_merging_cut ! PDGs for two cuts above
```

Set ktdurham > 0

# EXERCISES: CKKW-L MERGING

- Edit the **pythia8\_card.dat**

**Specify the process information**  
**Note that for xd is a new particle to pythia8**

```
! Parameters relevant only when performing CKKW-L merging, which can
! be turned on by setting the parameter 'ptlund' *or* 'ktDurhan' to
! a positive value.
! For details, see section 'CKKW-L Merging' on the left-hand menu of
! http://home.thep.lu.se/~torbjorn/pythia81html/Welcome.html
! -----
! Central merging scale values you want to be used.
! If equal to -1.0, then MadGraph5_aMC@NLO will set this automatically
! based on the parameter 'ktDurhan' of the run_card.dat
Merging:TMS = -1.0
! This must be set manually, according to Pythia8 directives.
! An example of possible value is 'pp>LEPTONS,NEUTRINOS'
! Alternatively, from Pythia v8.223 onwards, the value 'guess' can be
! used to instruct Pythia to guess the hard process. The guess would mean
! that all particles apart from light partons will be considered as a part
! of the hard process. This guess is prone to errors if the desired hard
! process is complicated (i.e. contains light partons). The user should
! then be wary of suspicious error messages in the Pythia log file.
Merging:Process = pp>{xd,52}{xd~,~52}
! A value of -1 means that it is automatically guessed by MadGraph.
! It is however always safer to explicitly set it.
Merging:nJetMax = -1
!
! For all merging schemes, decide whether you want the merging scale
! variation computed for only the central weights or all other
! PDF and scale variation weights as well
SysCalc:fullCutVariation = off
!
```

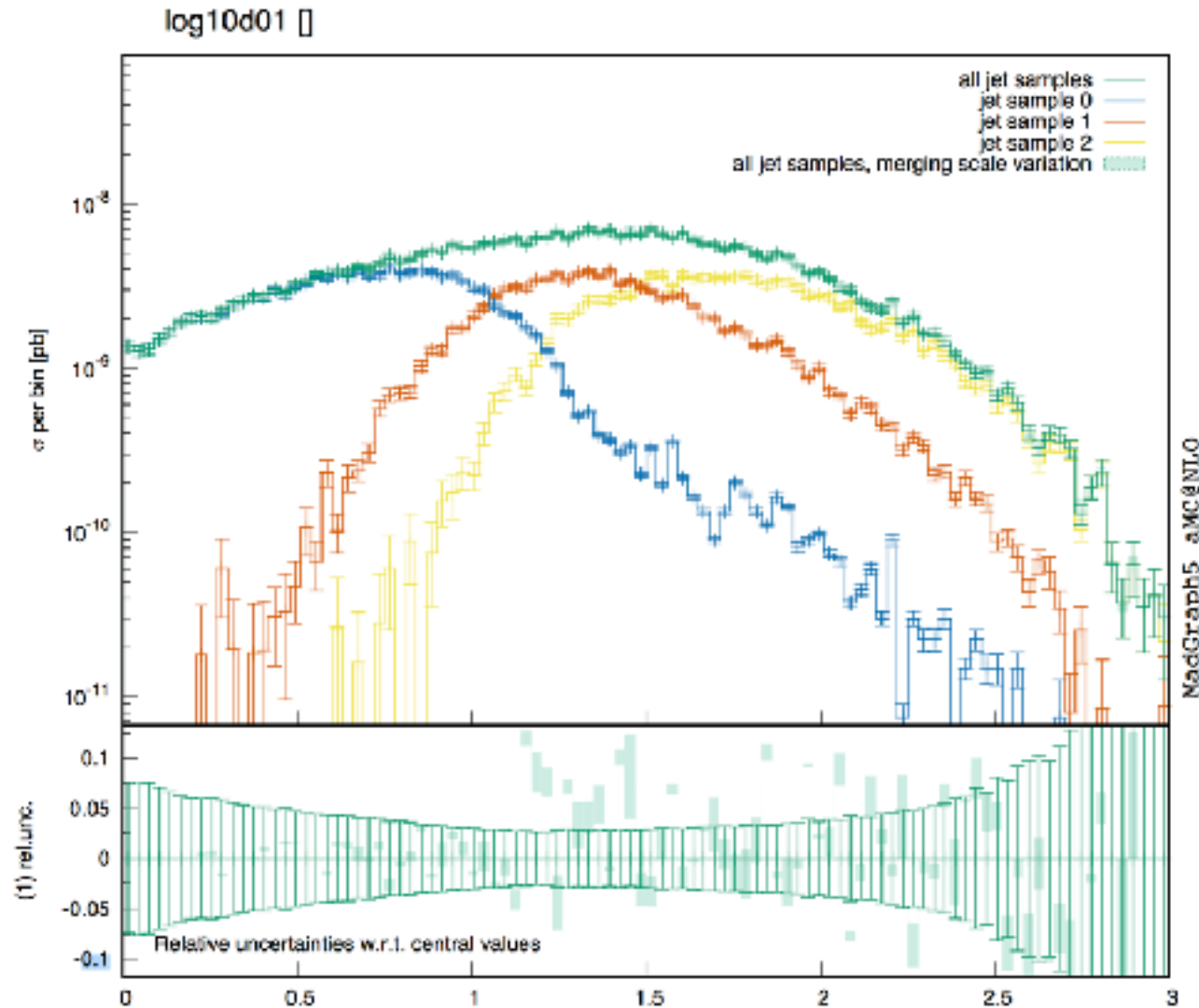
```
Merging:mayRemoveDecayProducts=on
```

**Ignore the on-shell resonances in the Les Houches event file**



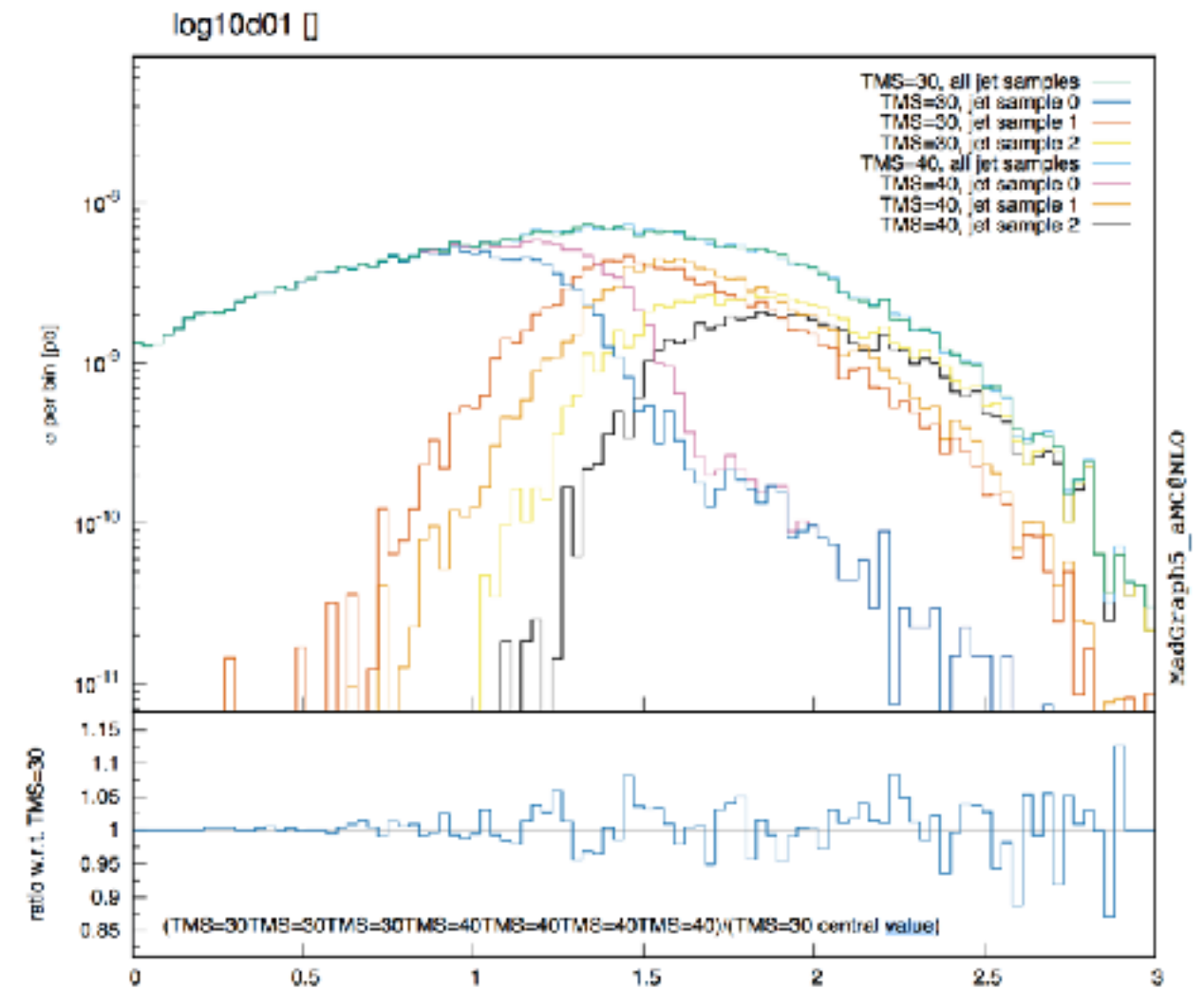
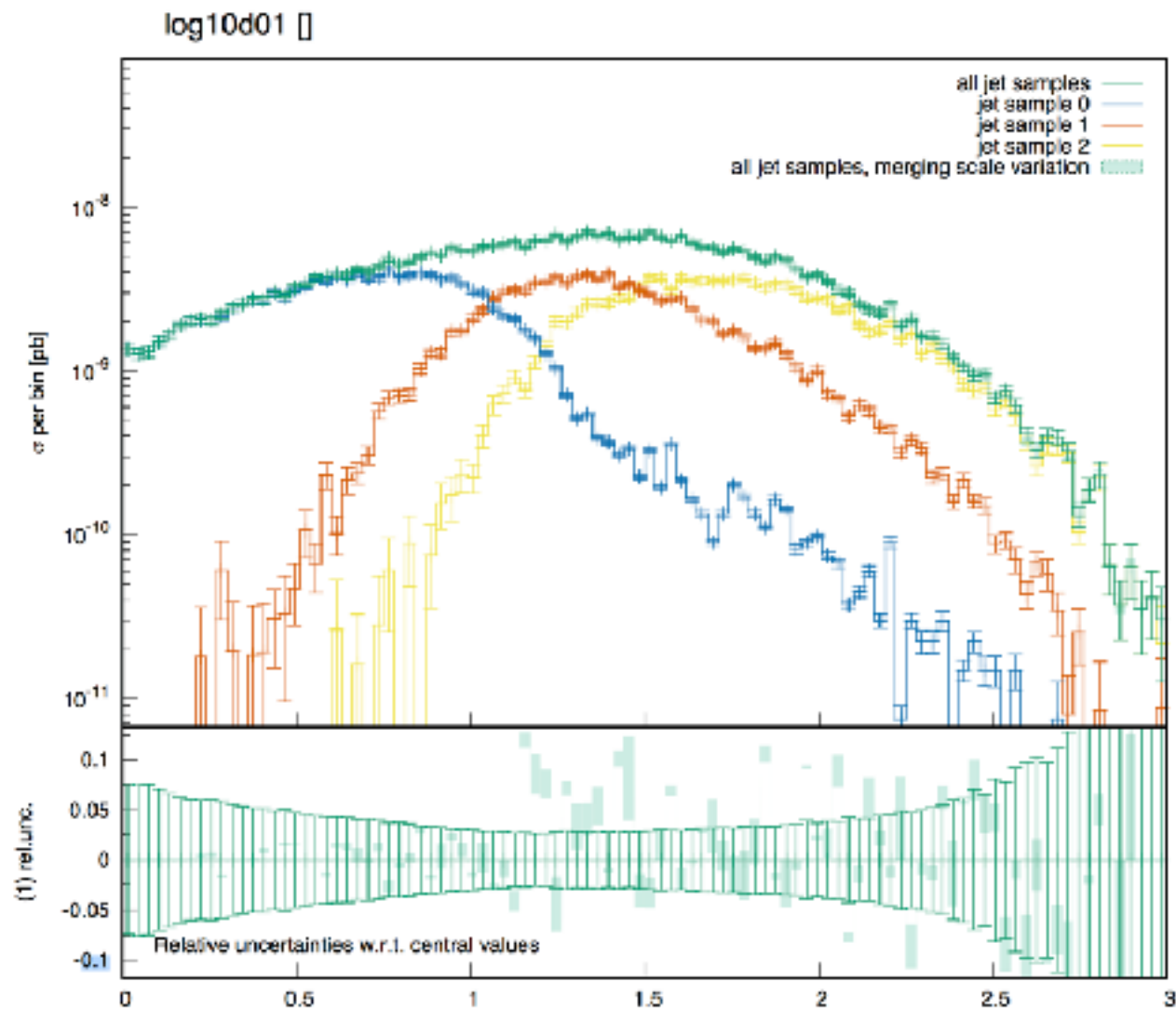
# EXERCISES: CKKW-L MERGING

- Check the smoothness of DJR curves



# EXERCISES: CKKW-L MERGING

- Check the smoothness of DJR curves
- Check the merging scale dependence



# EXERCISES: MLM MERGING

- Edit the `run_card.dat`

```
73. Running: 8, Completed: 53 [ 2m 6s ]
#####
# Matching parameter (MLM only)
#####
1=1 ! 0: no matching, 1: MLM
1.0= alpsfact ! scale factor for QCD emission vx
False= chcluster ! cluster only according to channel diag
5=5 asrwtflavor ! highest quark flavor for a_s reweight
False=Sh=auto_ptj_mjj ! Automatic settings of ptj and mjj if xqcut > 0
HELAS MyExample! (turn off for VBF and single top processes)
10.0 Too= xqcut ! minimum ktTjet measure between partons
```

***xqcut should be smaller than the hard scale (at least half)***

```
#####
# Turn on either the ktdurham or ptlund cut to activate
# CKKW(L) merging with Pythia8 [arXiv:1410.3012, arXiv:1109.4829]
#####
-1.0 = ktdurham
0.4 = dparameter
-1.0 = ptlund
1, 2, 3, 4, 5, 6, 21, 82 = page for merging cut ! PDGs for two cuts above
```

**Remember to turn off the CKKW-L merging**

# EXERCISES: MLM MERGING

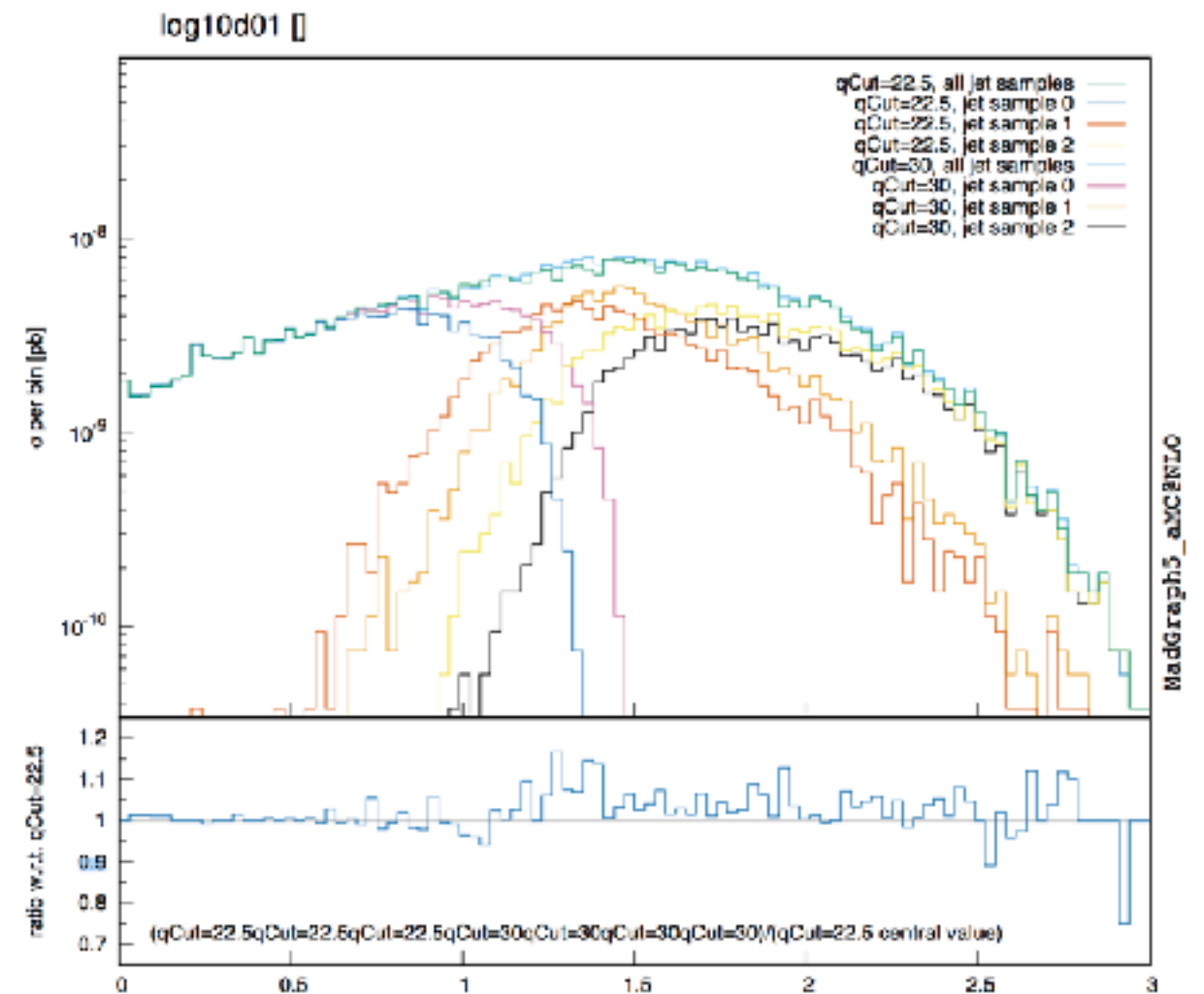
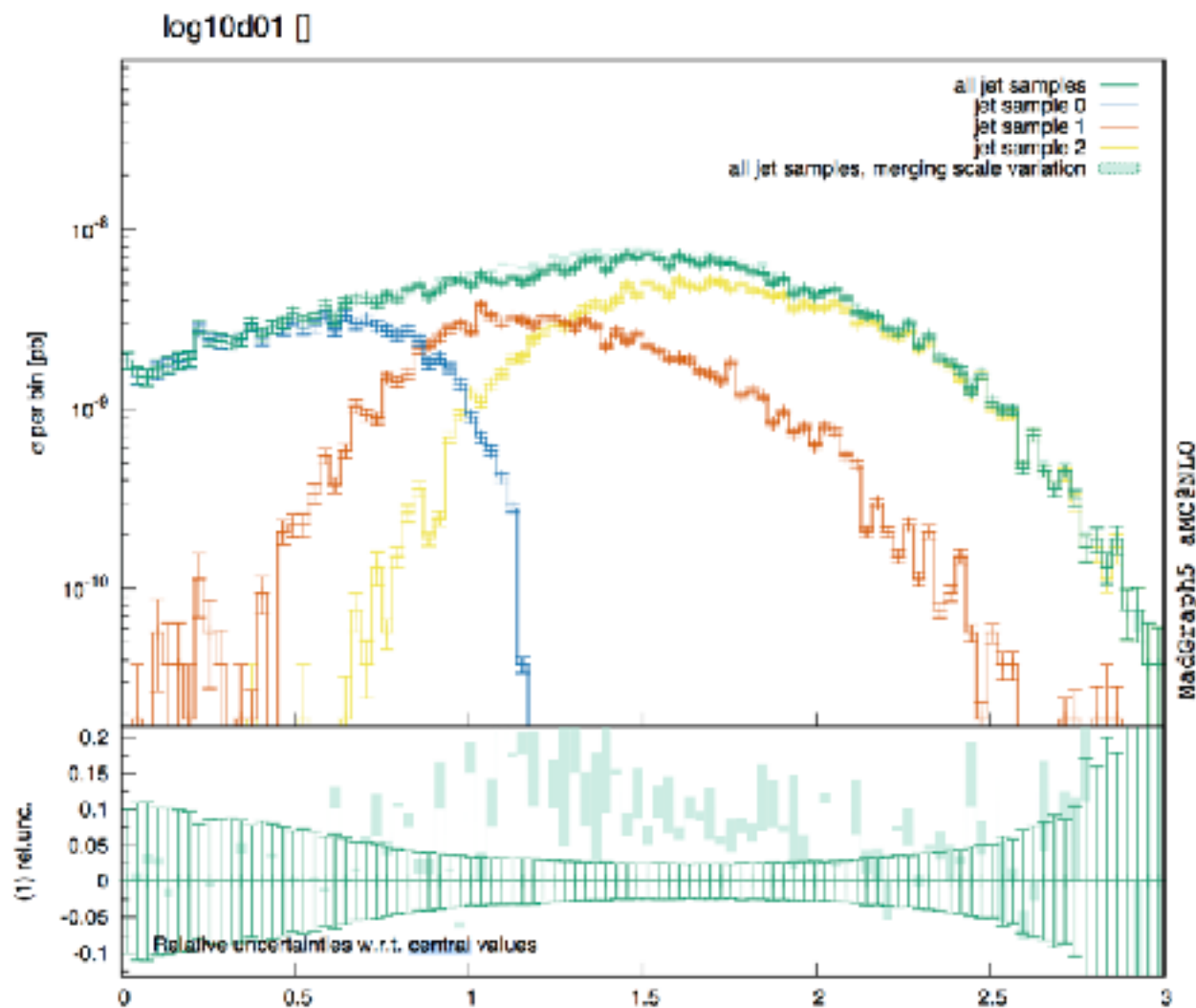


- Edit the `pythia8_card.dat`

```
Merging:mayRemoveDecayProducts=on
```

*Ignore the on-shell resonances in the Les Houches event file*

- Check the DJR distributions



# TAKE HOME EXERCISES



- Do the same things for the background processes

$$pp \rightarrow v_l \bar{v}_l \quad pp \rightarrow v_l \bar{v}_l + j \quad pp \rightarrow v_l \bar{v}_l + jj$$

- **Hint:** check the process information the Pythia8 webpage <http://home.thep.lu.se/~torbjorn/pythia8/html/Welcome.html>
- Do the CKKW-L and MLM merging without generating 0 jet sample.
  - **Hint:** Put 'j' in Merging:Process in `pythia8_card.dat` and put jet pT cut via 'ptj l min' in `run_card.dat`.