

Matching/Merging Tutorial

matching in MadGraph+Pythia

Example: Simulation of $pp \rightarrow W$ with 0, 1, 2 jets
(comfortable on a laptop)

```
mg5> generate p p > w+, w+ > l+ vl @0
mg5> add process p p > w+ j, w+ > l+ vl @1
mg5> add process p p > w+ j j, w+ > l+ vl @2
mg5> output
```

In run_card.dat:

```
...
1 = ickkw
...
0 = ptj
...
15 = xqcut
```

Matching on

No cone matching

k_T matching scale

Matching automatically done when run through
MadEvent and Pythia!

Merging scale can be defined in PY8 card (or left auto)

matching in MadGraph+Pythia

- By default, k_T -MLM matching is run if $xqcut > 0$, with the matching scale $QCUT = \max(xqcut * 1.4, xqcut + 10)$
- For shower- k_T , by default $QCUT = xqcut$
- If you want to change the Pythia setting for matching scale or switch to shower- k_T matching:

```
In pythia_card.dat:
```

```
...
```

```
! This sets the matching scale, needs to be > xqcut
```

```
QCUT = 30
```

```
! This switches from  $k_T$ -MLM to shower- $k_T$  matching
```

```
! Note that MSTP(81)>=20 needed (pT-ordered shower)
```

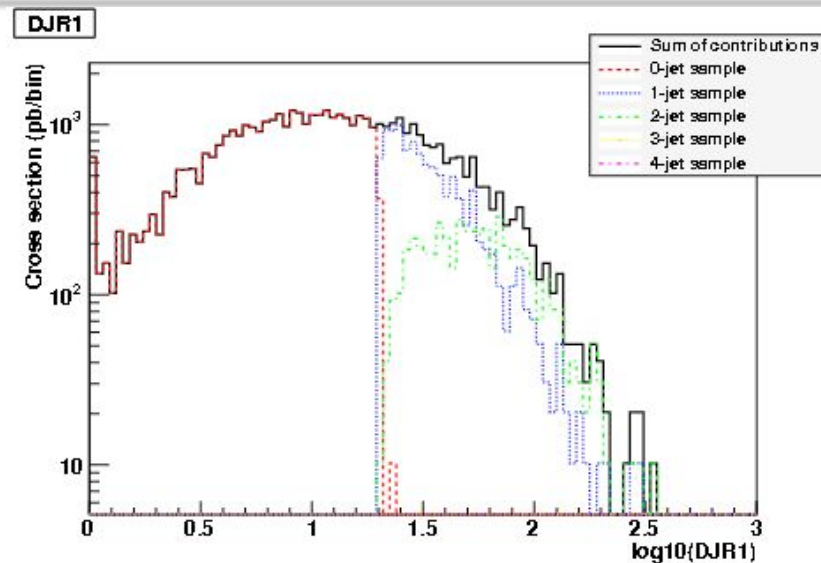
```
SHOWERKT = T
```

How to do validate the matching

- The matching scale (QCUT) should typically be chosen around $1/6$ - $1/2$ x hard scale (so x_{qcut} correspondingly lower)
- The matched cross section (for $X+0, 1, \dots$ jets) should be close to the unmatched cross section for the 0-jet sample (found on the process HTML page)
- The differential jet rate plots should be smooth
- When QCUT is varied (within the region of validity), the matched cross section or differential jet rates should not vary significantly

Differential Jet Rate Plot

- This are the clustering scales in the kt-jet clustering scheme
- DJR1: p_T of the last remaining jet
- DJR2: The **minimum** between the p_T of the second to last remaining jet **and** the kt between the last two jet.
- Only radiative jet (not those from decay) should enter those plot.

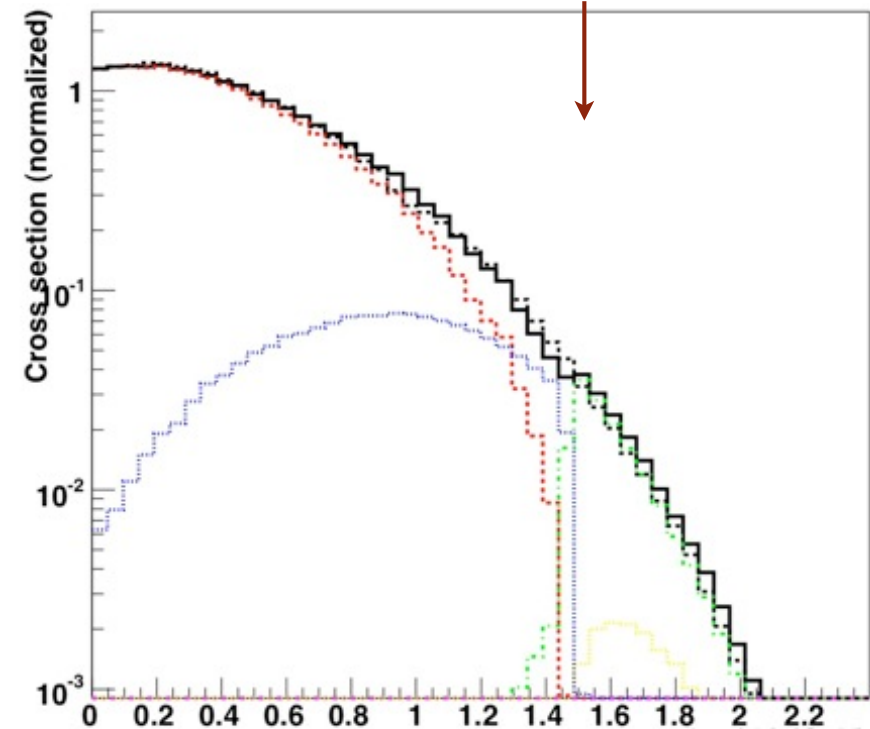
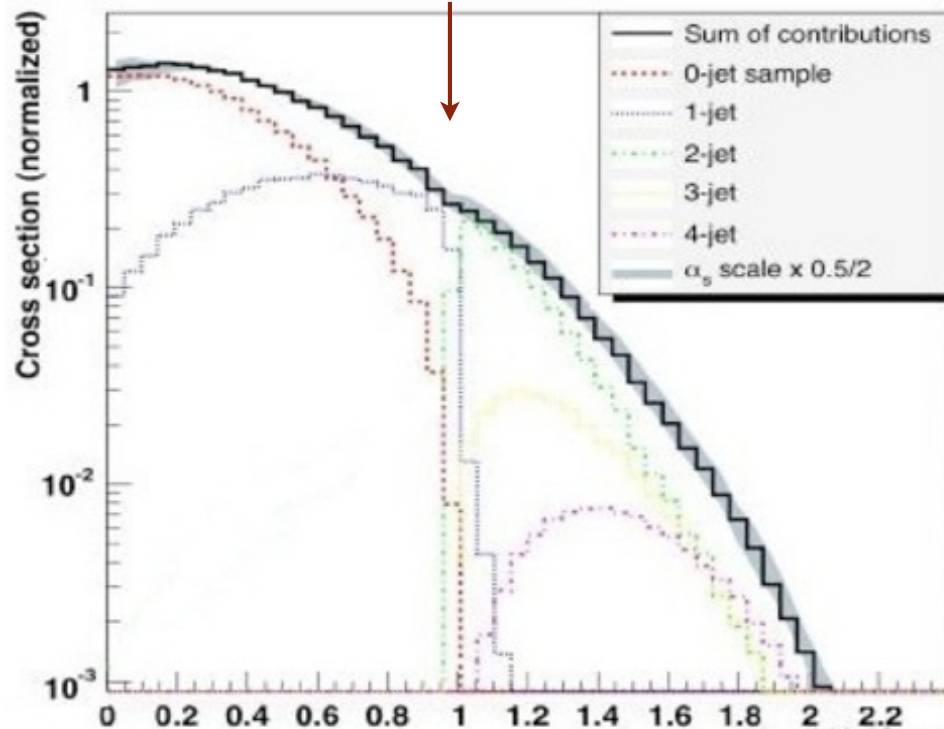


Matching Validation

W+jets production at the Tevatron for MadGraph+Pythia
(k_T -jet MLM scheme, q^2 -ordered Pythia showers)

$Q_{\text{match}} = 10 \text{ GeV}$

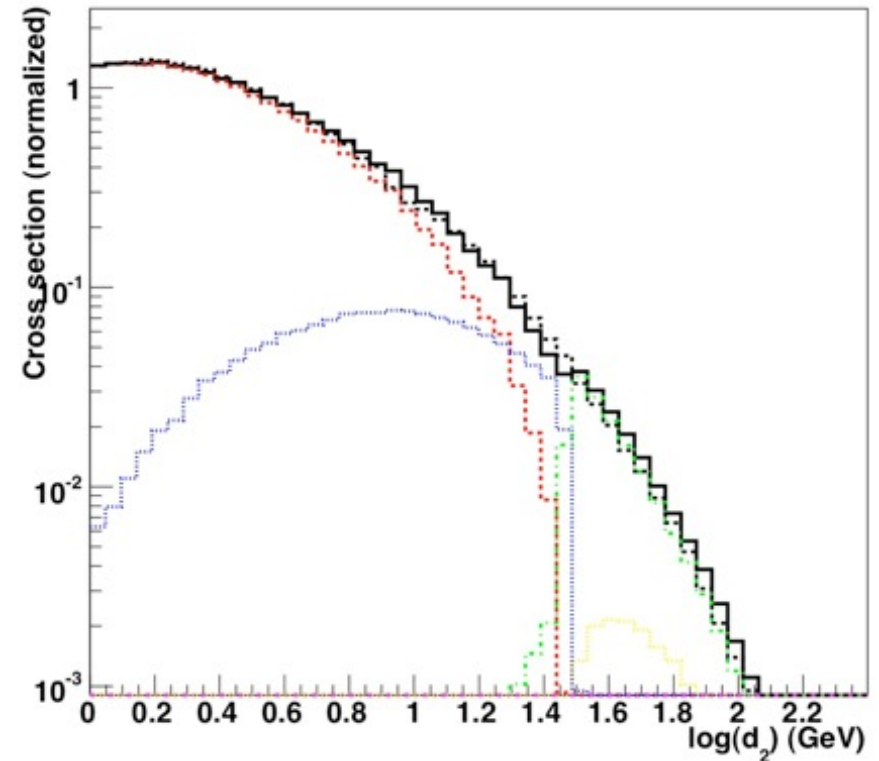
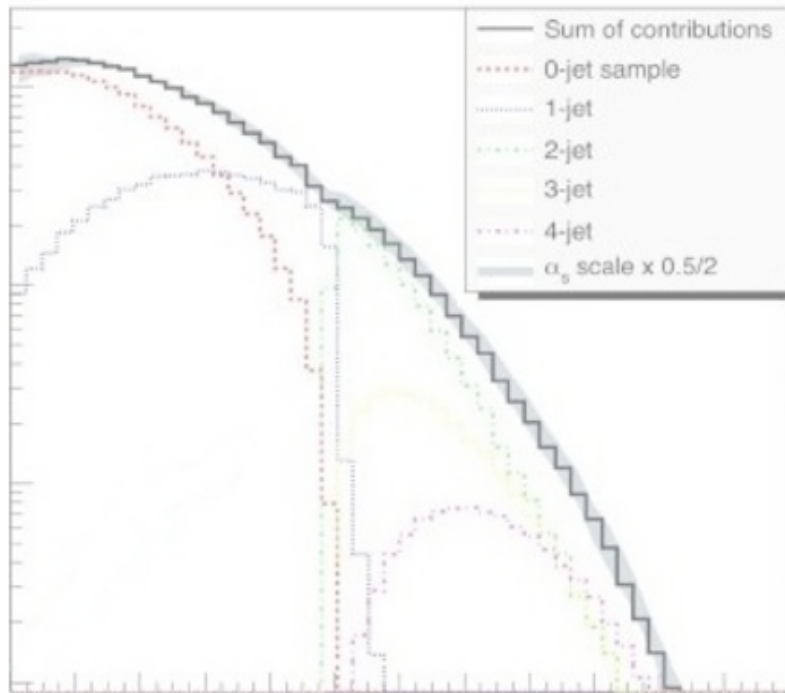
$Q_{\text{match}} = 30 \text{ GeV}$



$\log(\text{Differential jet rate for } 1 \rightarrow 2 \text{ radiated jets} \sim p_T(2\text{nd jet}))$

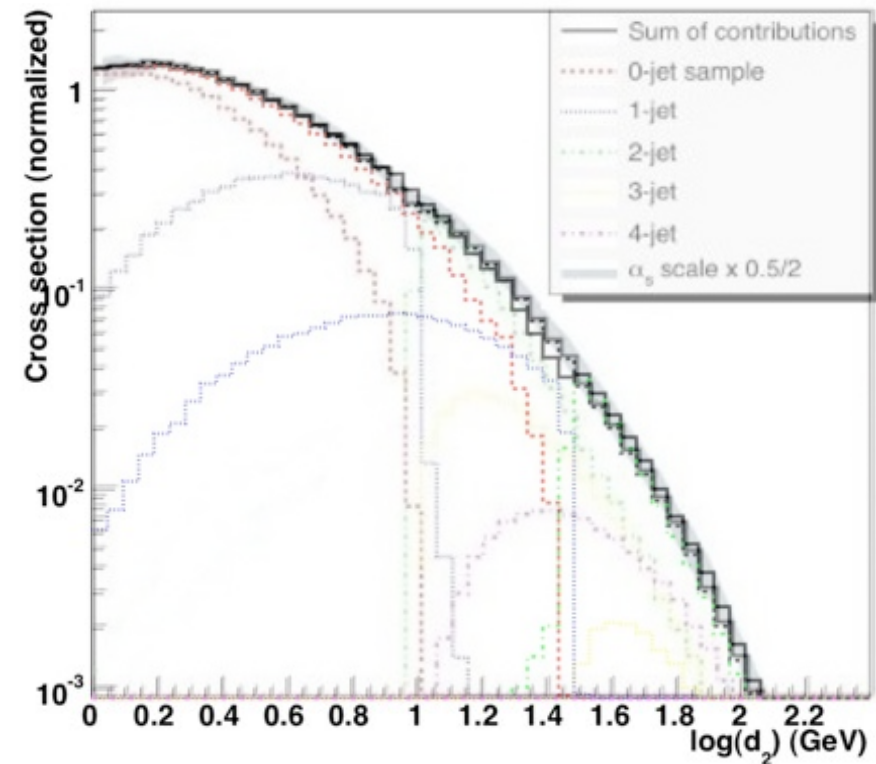
Matching Validation

W+jets production at the Tevatron for MadGraph+Pythia
(k_T -jet MLM scheme, q^2 -ordered Pythia showers)



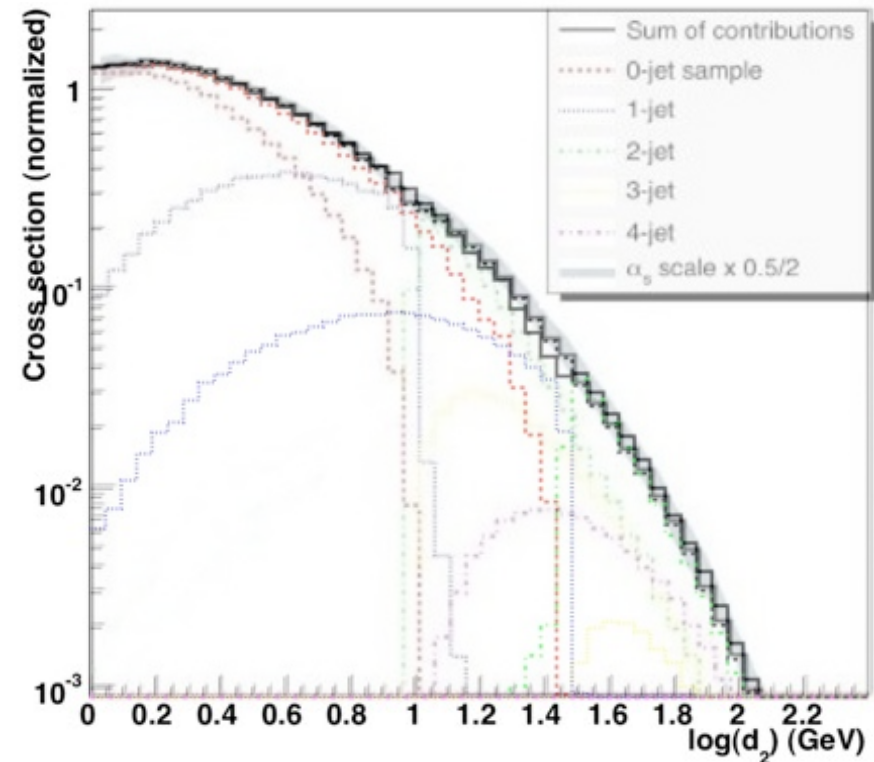
Matching Validation

W+jets production at the Tevatron for MadGraph+Pythia
(k_T -jet MLM scheme, q^2 -ordered Pythia showers)



Matching Validation

W+jets production at the Tevatron for MadGraph+Pythia
(k_T -jet MLM scheme, q^2 -ordered Pythia showers)



Jet distributions smooth, and stable when we vary the matching scale!

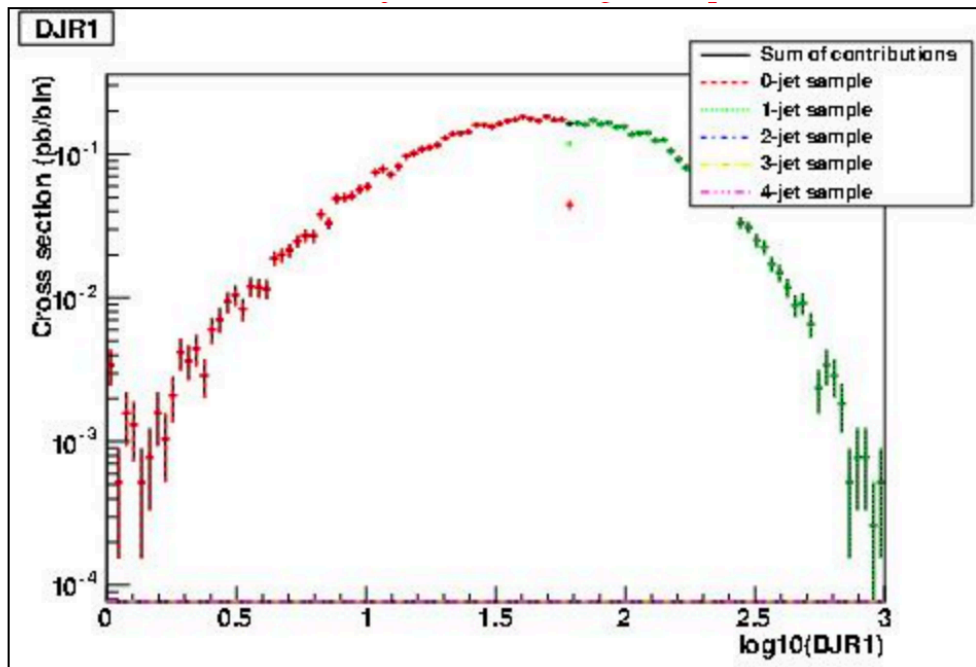
Lecture Summary

- Despite the apparent enormous complexity of simulation of complete collider events, nature has kindly allowed us to factorize the simulation into separate steps
- The Monte Carlo method allows us to step-by-step simulate hard scattering, parton shower, particle decays, hadronization, and underlying event
- Jet matching between matrix elements and parton showers gives crucial improvement of simulation of background as well as signal processes
- Running matching with MadGraph + Pythia is very easy, but the results should always be checked for consistency

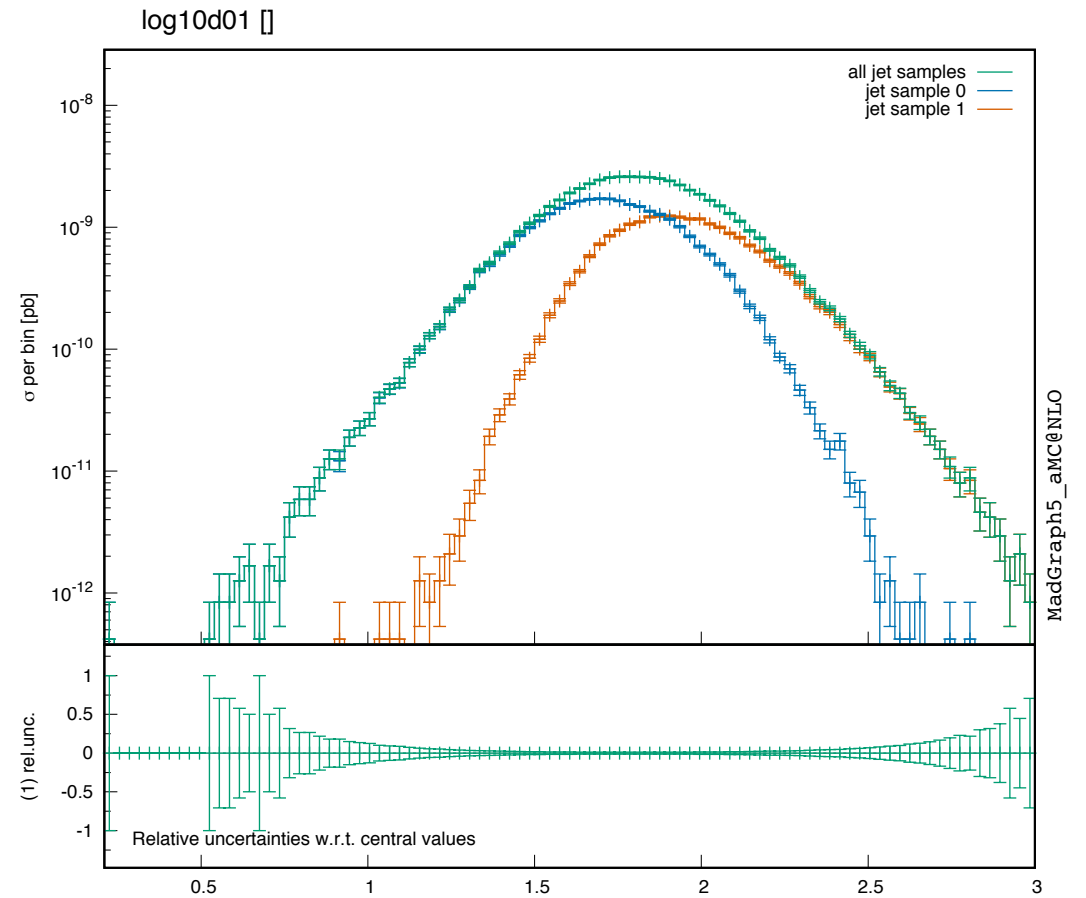
MLM

- Generate $p p \rightarrow t \bar{t}$
- Add process $p p \rightarrow t \bar{t} j$
- Output; Launch
 - ➔ Ask for MadSpin and Pythia8 and MA5
 - ➔ set mpi OFF # This is for speed issue for the tuto
 - ➔ decay $t \rightarrow w^+ b, w^+ \rightarrow e^+ \nu_e$
 - ➔ decay $\bar{t} \rightarrow w^- \bar{b}, w^- \rightarrow e^- \bar{\nu}_e$
 - ➔ set xqcut 30 #minimal distance between quark/gluon @tree-level
 - ➔ set jetmatching:Qcut 60 #the MLM matching scale

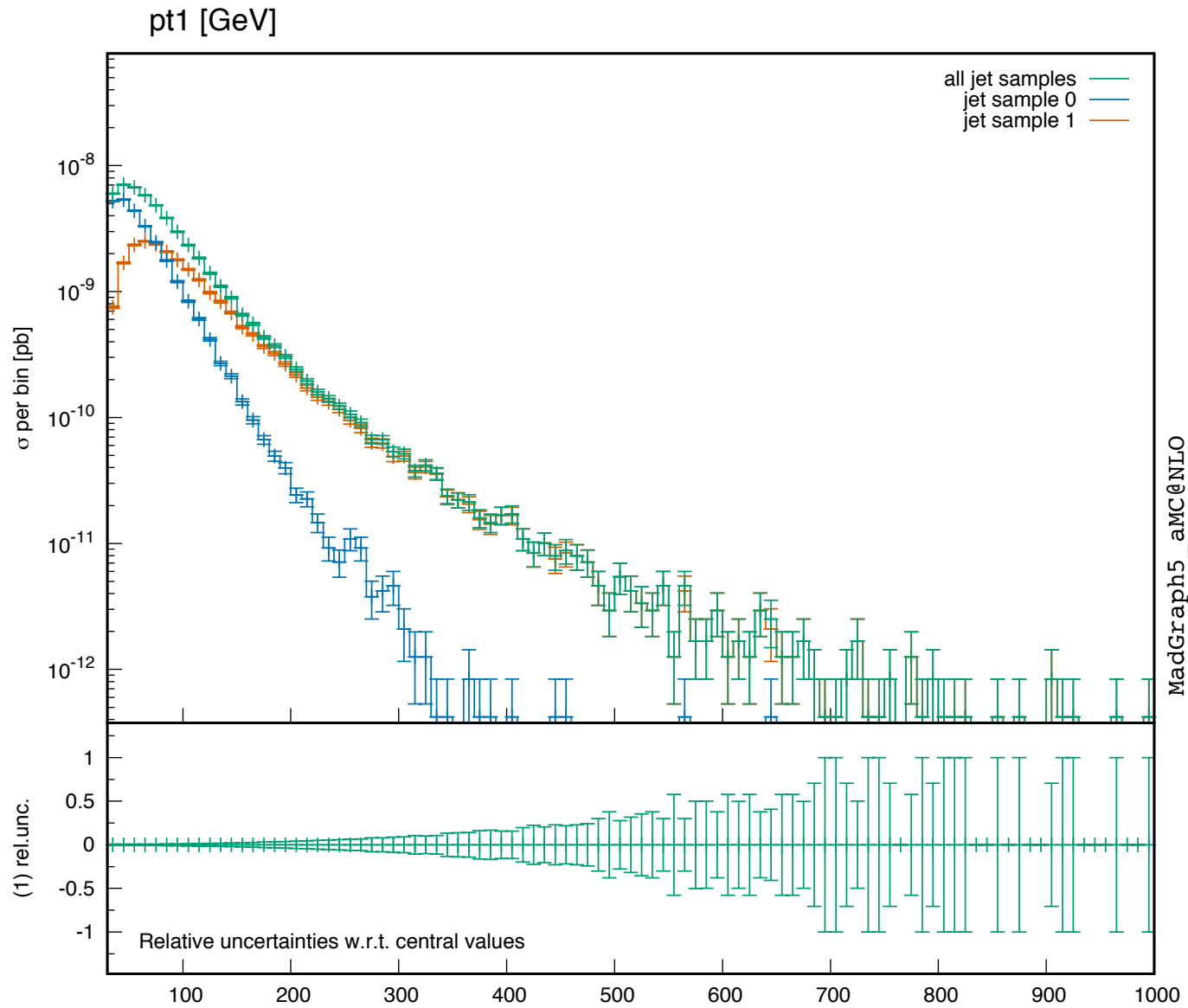
Validation of MLM



[Download PS DJR1.ps](#)



PT distribution



Exercise VI: Matching+Merging

	w+0j	w+1j	w+2j	w+3j
no matching	8,35E+04	1,58E+04	8,7E+03	3,5E+03

	1GeV	10GeV	20GeV	50GeV	100GeV	500GeV
w+0	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04
0+1	1,07E+05	9,09E+04	8,91E+04	8,61E+04	8,40E+04	8.35+04
0+1+2	1,12E+05	9,29E+04	9,03E+04	8,66E+04	8,44E+04	8,35E+04
0+1+2+3	1,20E+05	9,47E+04	9,07E+04	8,68E+04	8,40E+04	8,35E+04

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w+0	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04
0+1	1,07E+05	9,09E+04	8,91E+04	8,61E+04	8,40E+04	8.35+04
0+1+2	1,12E+05	9,29E+04	9,03E+04	8,66E+04	8,44E+04	8,35E+04
0+1+2+3	1,20E+05	9,47E+04	9,07E+04	8,68E+04	8,40E+04	8,35E+04

Slow
Fast
low efficiency
High efficiency

Exercise VI: Matching+Merging

- | | w+0j | w+1j | w+2j | w+3j |
|-------------|----------|----------|---------|---------|
| no matching | 8,35E+04 | 1,58E+04 | 8,7E+03 | 3,5E+03 |

	1GeV	10GeV	20GeV	50GeV	100GeV	500GeV
w+0	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04
0+1	1,07E+05	9,09E+04	8,91E+04	8,61E+04	8,40E+04	8.35+04
0+1+2	1,12E+05	9,29E+04	9,03E+04	8,66E+04	8,44E+04	8,35E+04
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w+0	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04
0+1	1,07E+05	9,09E+04	8,91E+04	8,61E+04	8,40E+04	8.35+04
0+1+2	1,12E+05	9,29E+04	9,03E+04	8,66E+04	8,44E+04	8,35E+04
0+1+2+3	1,20E+05	9,47E+04	9,07E+04	8,68E+04	8,40E+04	8,35E+04

Exercise VI: Matching+Merging

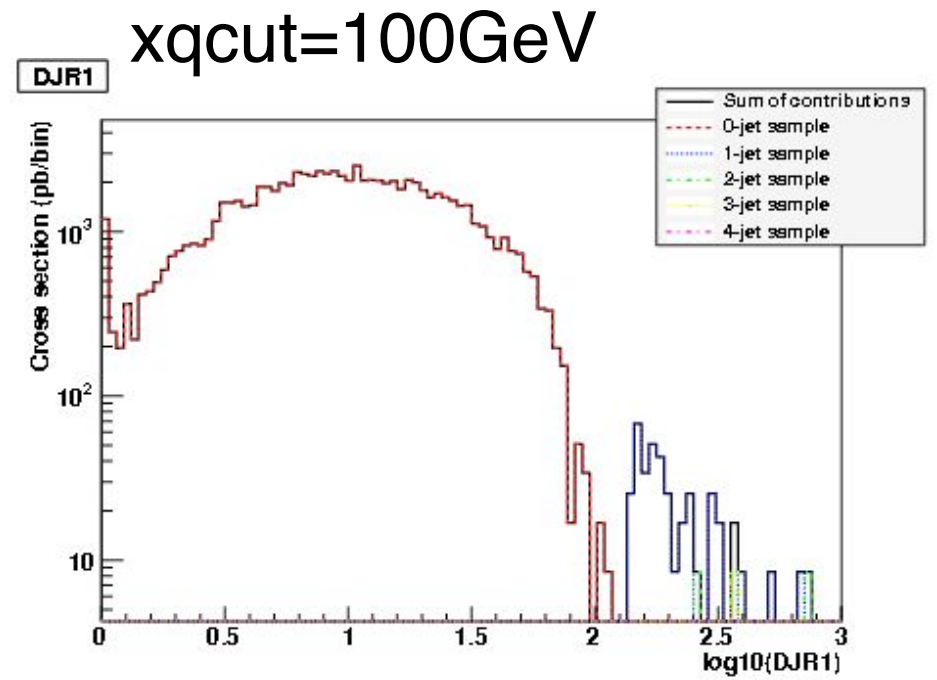
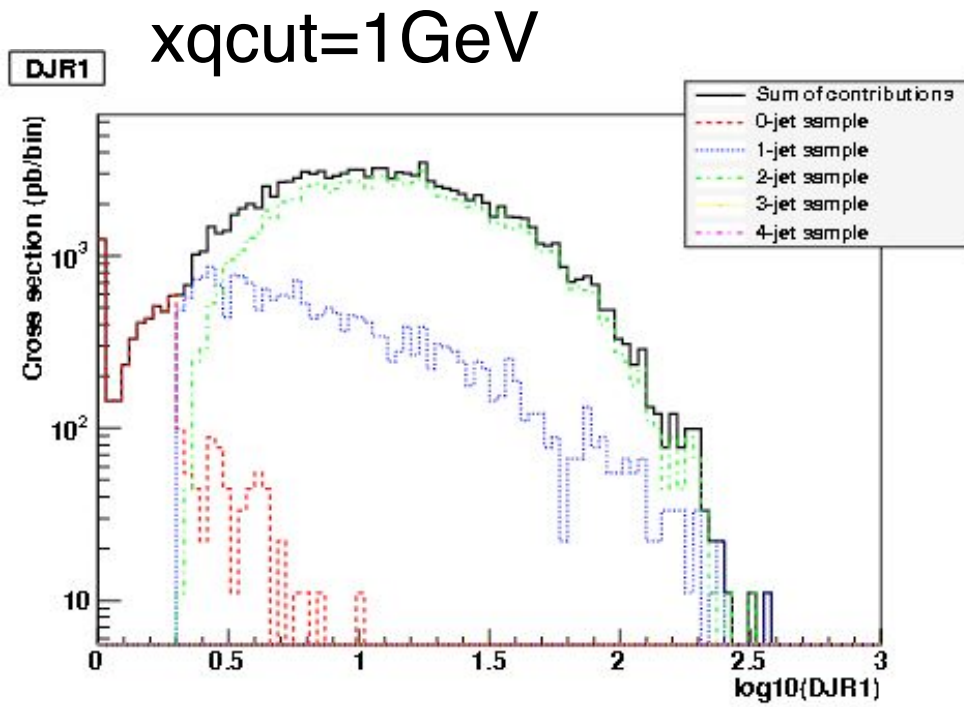
- | | w+0j | w+1j | w+2j | w+3j |
|-------------|----------|----------|---------|---------|
| no matching | 8,35E+04 | 1,58E+04 | 8,7E+03 | 3,5E+03 |

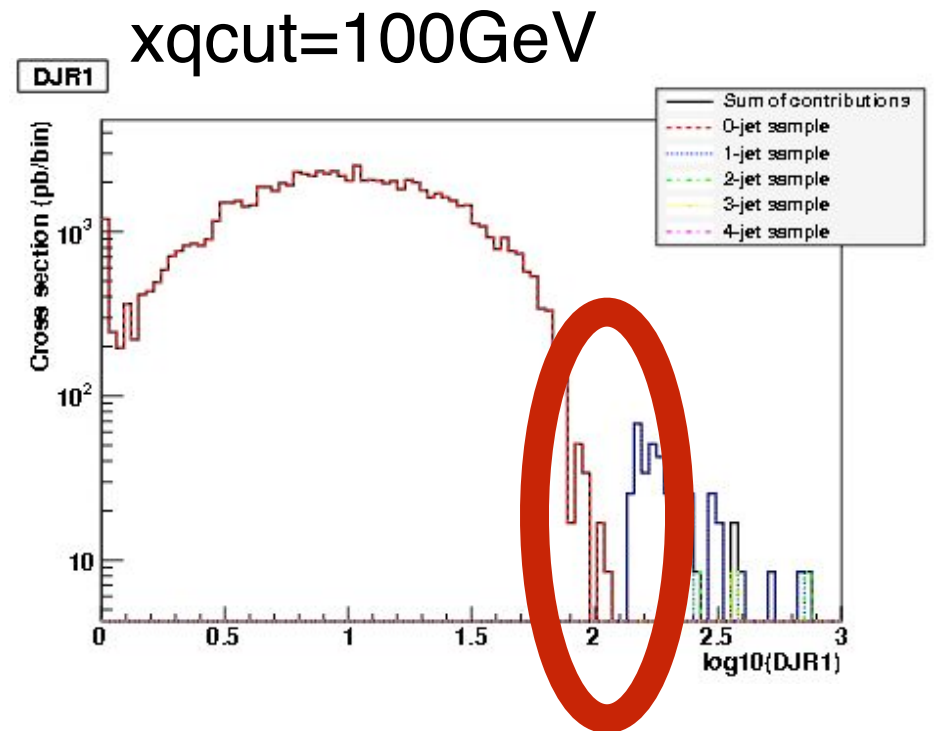
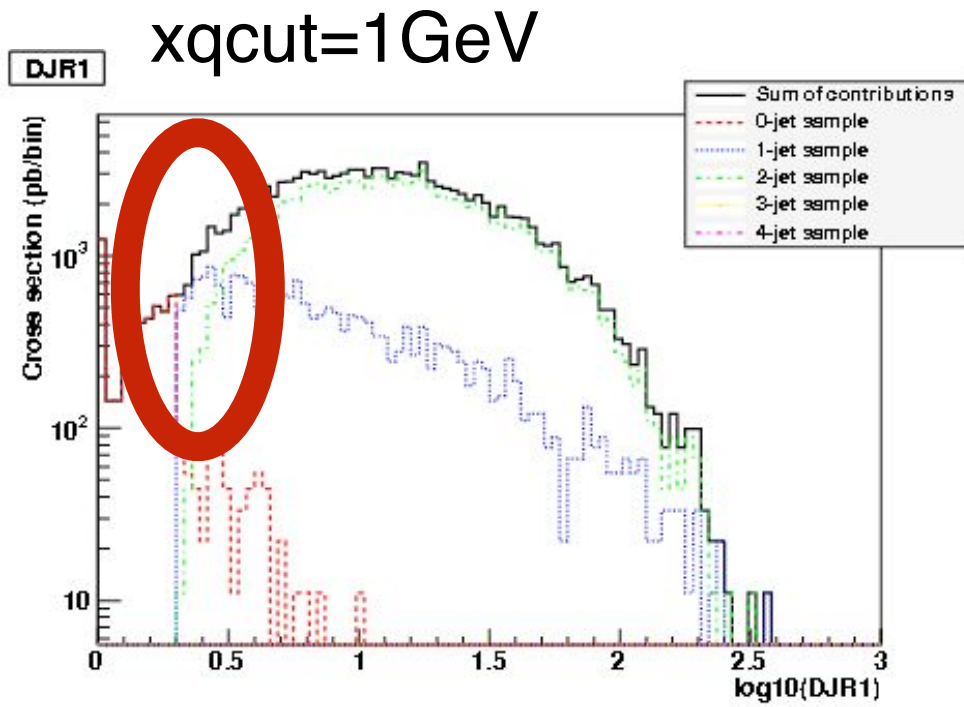
	1GeV	10GeV	20GeV	50GeV	100GeV	500GeV
w+0	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04
0+1	1,07E+05	9,09E+04	8,91E+04	8,61E+04	8,40E+04	8.35+04
0+1+2	1,12E+05	9,29E+04	9,03E+04	8,66E+04	8,44E+04	8,35E+04
0+1+2+3	1,20E+05	9,47E+04	9,07E+04	8,68E+04	8,40E+04	8,35E+04

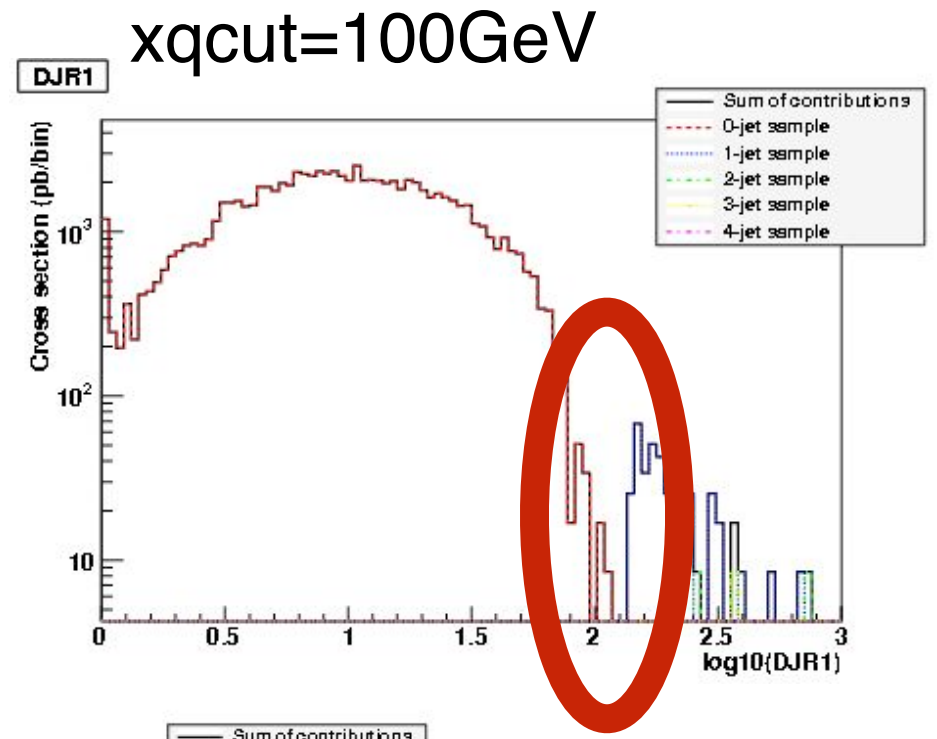
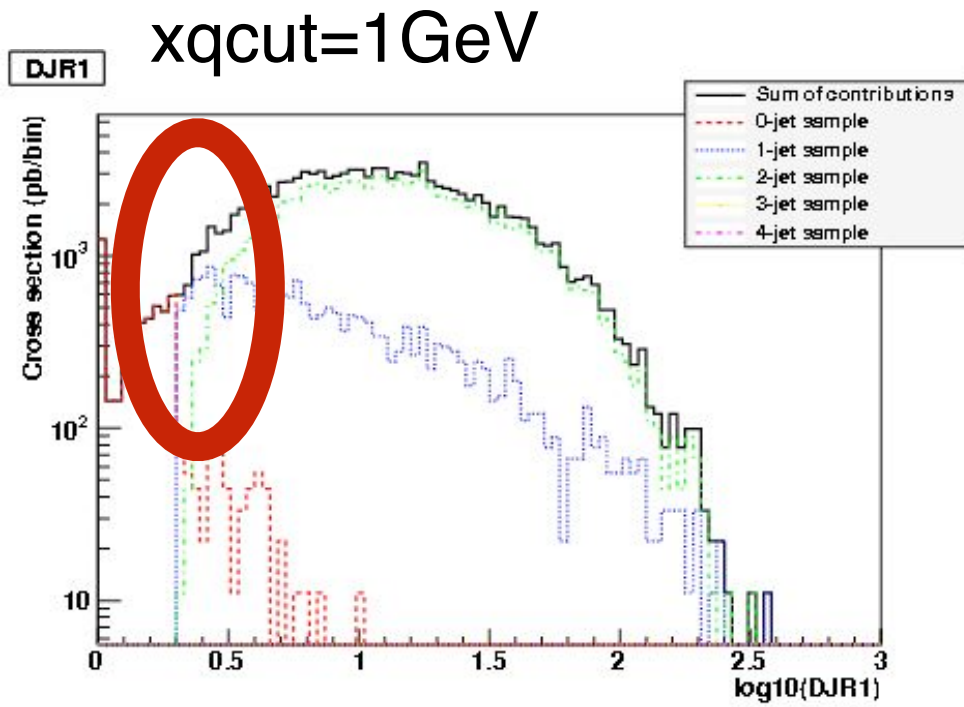
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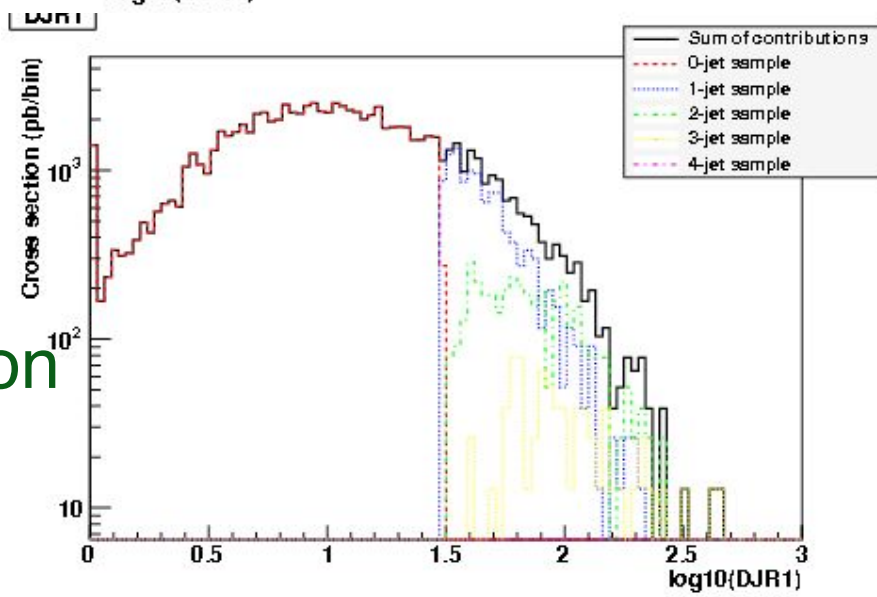
	1GeV	10GeV	20GeV	50GeV	100GeV	500GeV
w+0	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04	8,35E+04
0+1	1,07E+05	9,09E+04	8,91E+04	8,61E+04	8,40E+04	8,35E+04
0+1+2	1,12E+05	9,29E+04	9,03E+04	8,66E+04	8,44E+04	8,35E+04
0+1+2+3	1,20E+05	9,47E+04	9,07E+04	8,68E+04	8,40E+04	8,35E+04







$xqcut=20\text{ GeV}$
smooth transition



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- | | w+0j | w+1j | w+2j | w+3j |
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0+1+2	1,12E+05	9,29E+04	9,03E+04	8,66E+04	8,44E+04	8,35E+04
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