Matching Matrix Elements and Parton Showers with HERWIG

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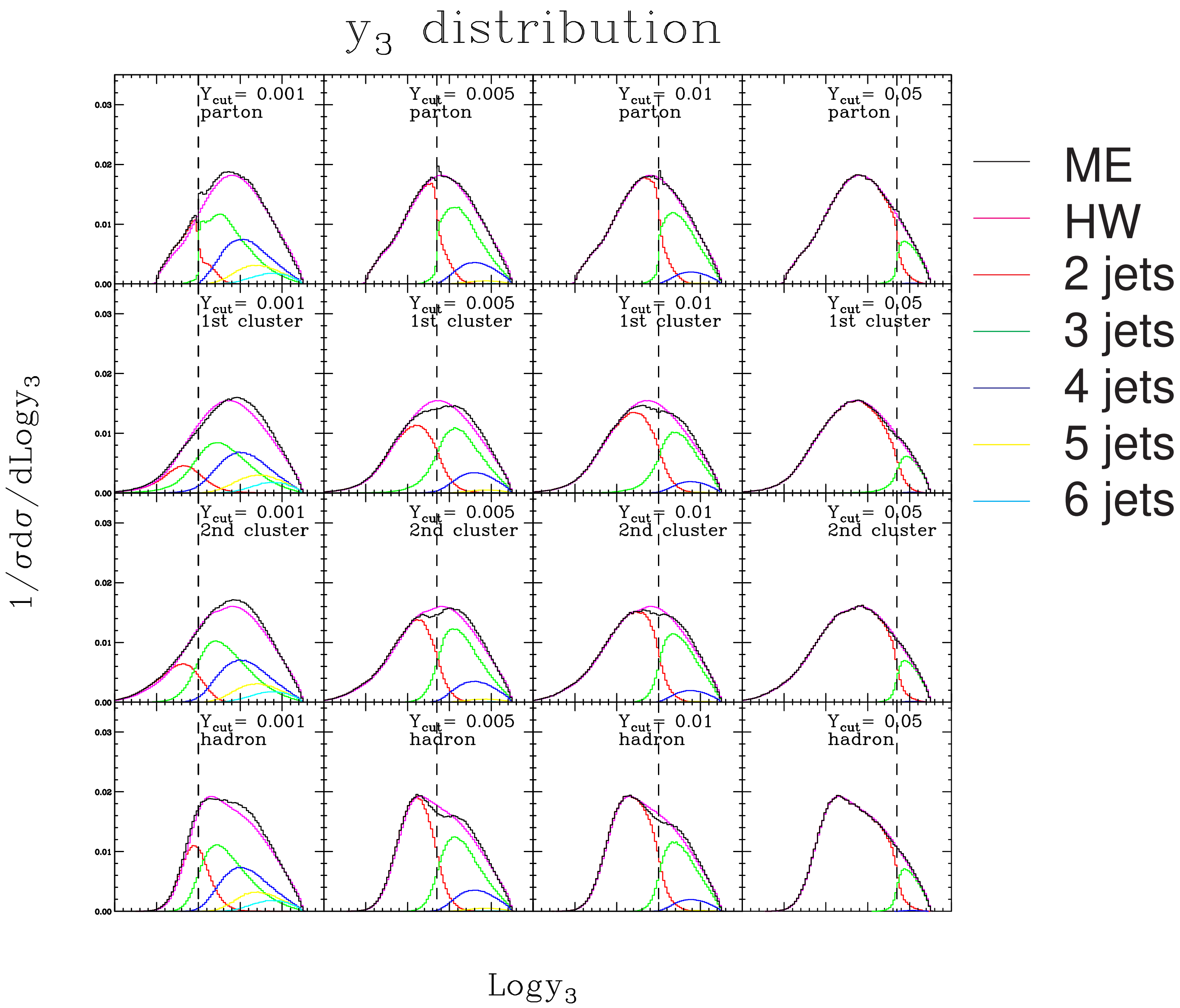
- e^+e^- collisions
- Hadron collisions
- Conclusions

e^+e^- collisions

- As we are supposed to be talking about hadron collisions I will only present some results from e^+e^- collisions to show:
  - the remaining problems;
  - Preliminary results with heavy quarks.

Hadronization Problems

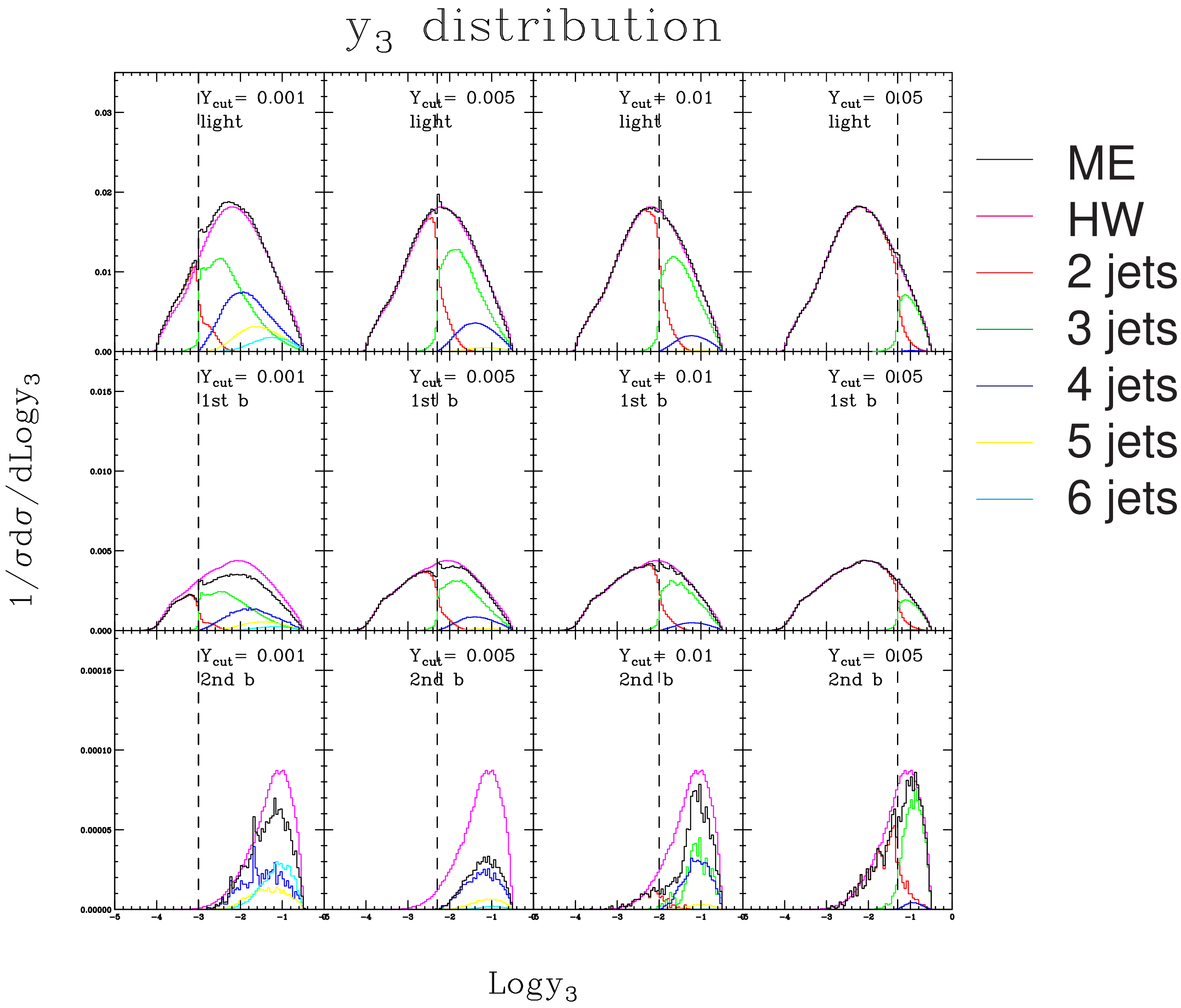
- There is one remaining problem with the hadronization.
- Little success in tuning it away.



Bottom Quarks

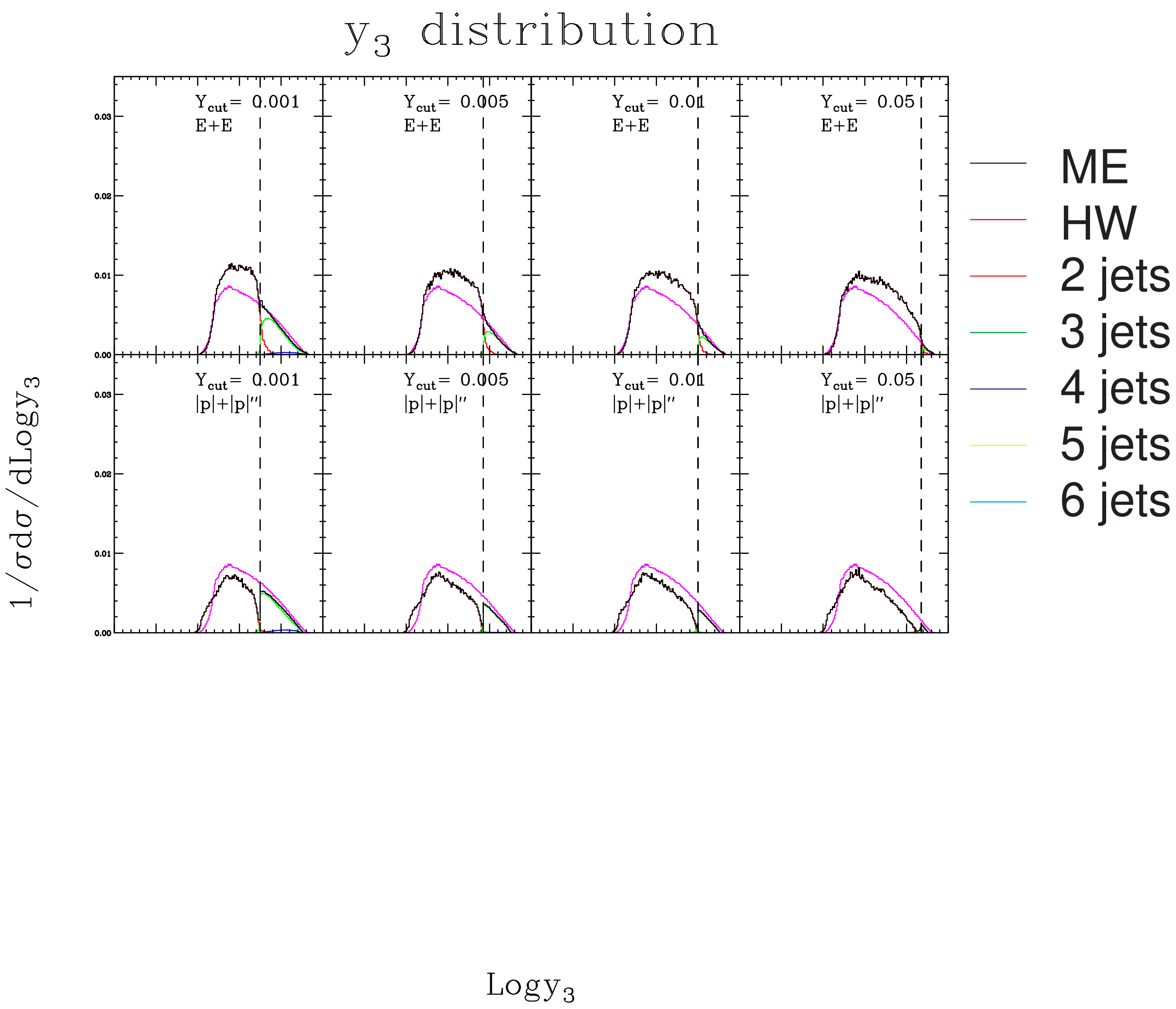
- First look at bottom quarks using full massive Sudakov for the bottom.
- The events were clustered after the parton shower using the same code as for the merging.
- Primary bottom quark events were those in which the last merging was $b\bar{b} \to Z$.
- Secondary bottoms was everything else containing a $b\bar{b}$ pair.

Bottom Quarks



Top Quarks

- Things look worse with top.
- Can we apply the approach for top and if so how?



Hadron Collisions

- In hadron collisions in addition to final-state radiation we have the problems of initial-state radiation.
- We also have a greater choice of the clustering algorithm.

Hadron Collisions

- I will consider three choices.
  - E-scheme

$$
\begin{aligned}
d_{iB} &= 2E_i^2(1-\cos\theta_{iB}), \\
d_{ij} &= 2\min(E_i^2, E_j^2)(1-\cos\theta_{ij}).
\end{aligned}
$$

    Combine 4-momenta to get pseudoparticles
  - Covariant E-scheme

$$
\begin{aligned}
d_{iB} &= p_{ti}^2, \\
d_{ij} &= \min(p_{ti}^2, p_{tj}^2)R_{ij}^2,
\end{aligned}
$$

    Combine 4-momenta to get pseudoparticles
  - Covariant monotonic p_T^2 scheme
    Same definition of d as Covariant E-scheme but define p_t and R for pseudoparticles as

$$
\begin{aligned}
p_{t(ij)} &= p_{ti} + p_{tj}, \\
R_{(ij)k}^2 &= \frac{p_{ti}^2 R_{ik}^2 + p_{tj}^2 R_{jk}^2}{p_{ti}^2 + p_{tj}^2}.
\end{aligned}
$$

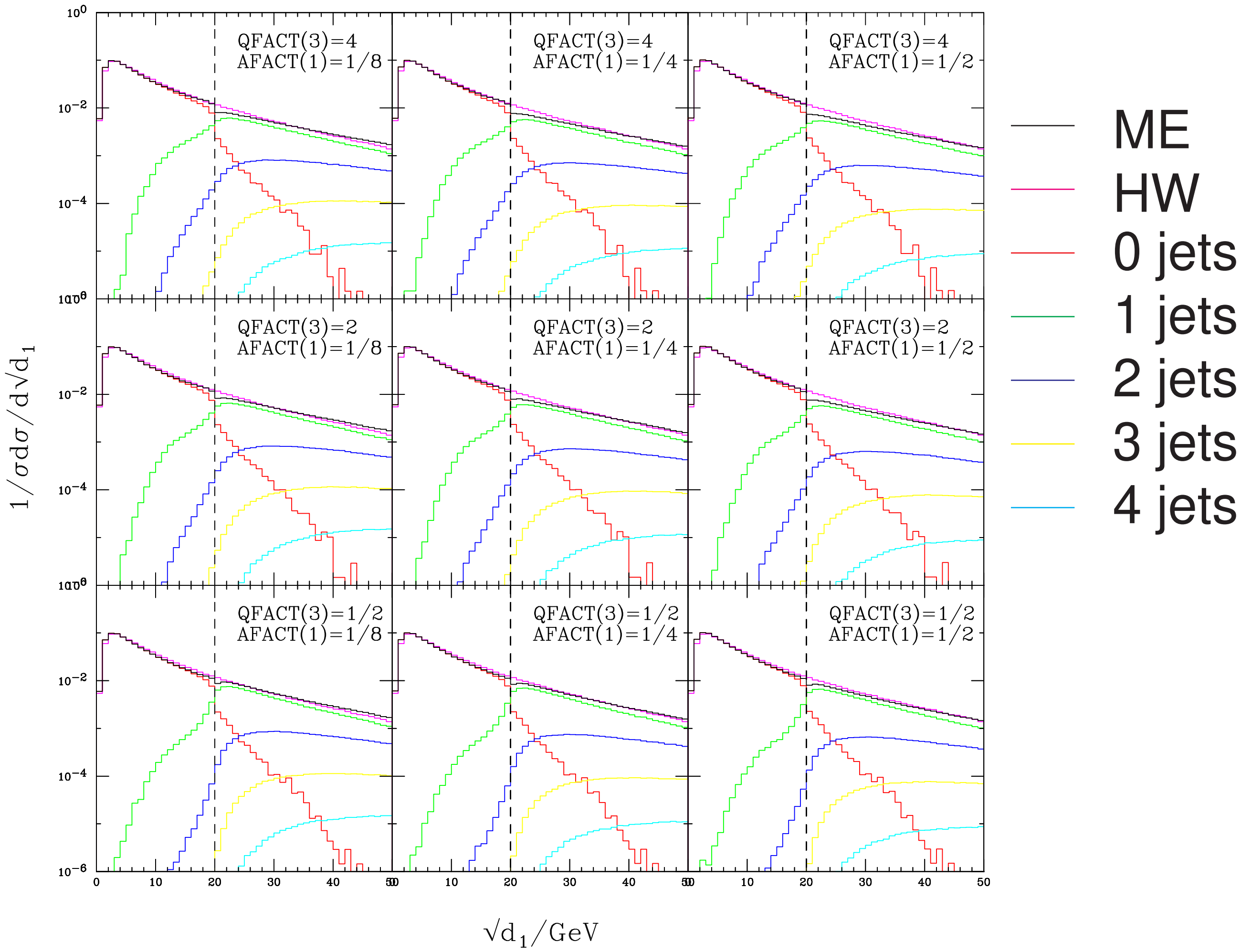
Hadron Collisions

- Start by considering W and Z production at the Tevatron.
- Use the Covariant monotonic p_T^2 scheme.
- and a matching scale of $400\ \mathrm{GeV}^2$.
- Look at the differential cross section with respect to $\sqrt{d_n}$ where d_n is the scale at which n jets are resolved.
- This is like the E_T in a cone algorithm.

W Production

- Variation of results with scale of α_S and starting scale of shower.

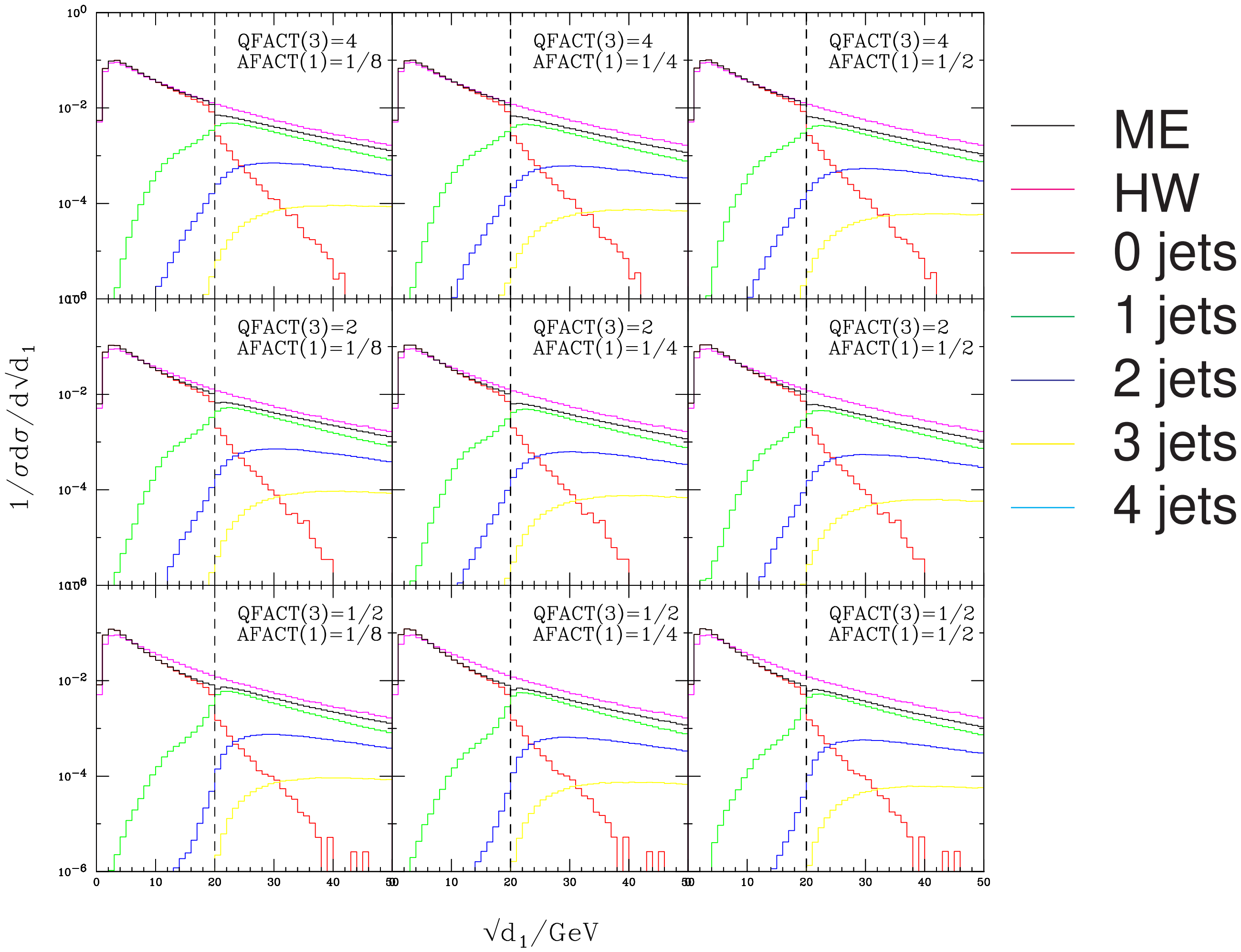
- d_1 distribution at the Tevatron



Z Production

- Variation of results with scale of α_S and starting scale of shower.

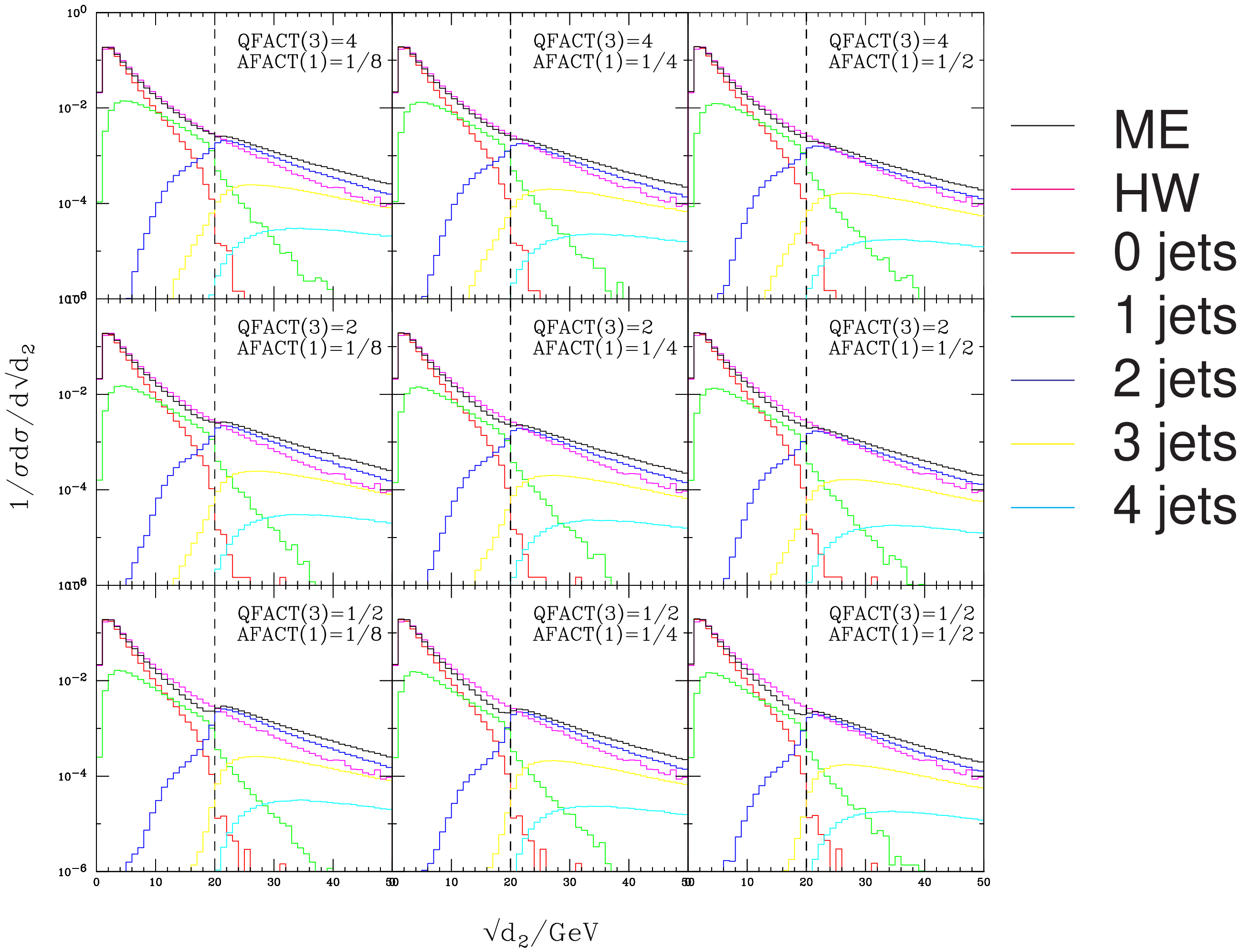
- d_1 distribution at the Tevatron



W Production

- Variation of results with scale of α_S and starting scale of shower.

- d_2 distribution at the Tevatron

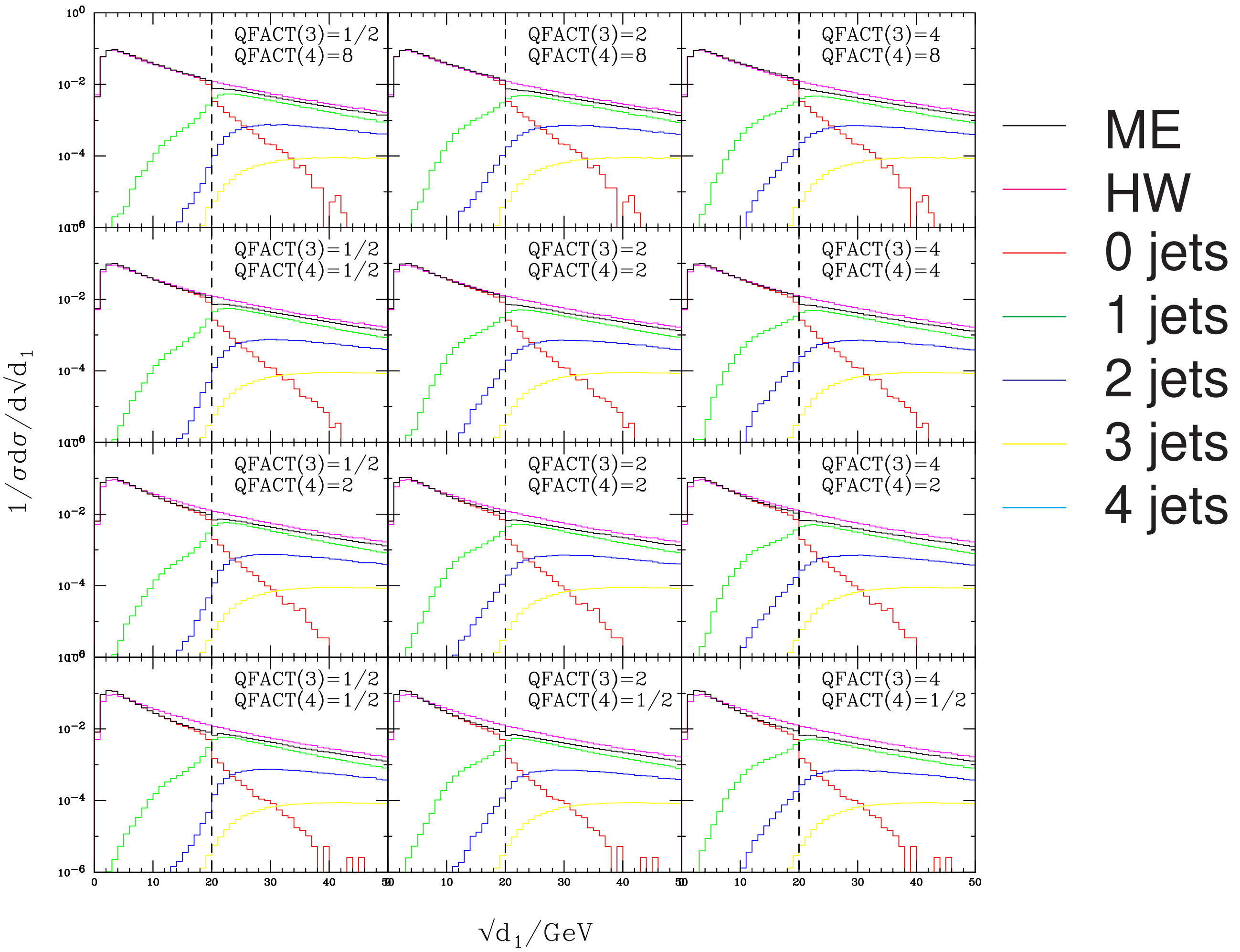


Hadron Collisions

- There is a radiation dip at the matching scale $\Rightarrow$ high `QFACT(3)`.
- However there is also a problem with events migrating below the matching scale $\Rightarrow$ low `QFACT(3)`.
- Solution is to decouple the scale for the initial-state shower `QFACT(4)` from the scale for the final-state shower `QFACT(3)`?

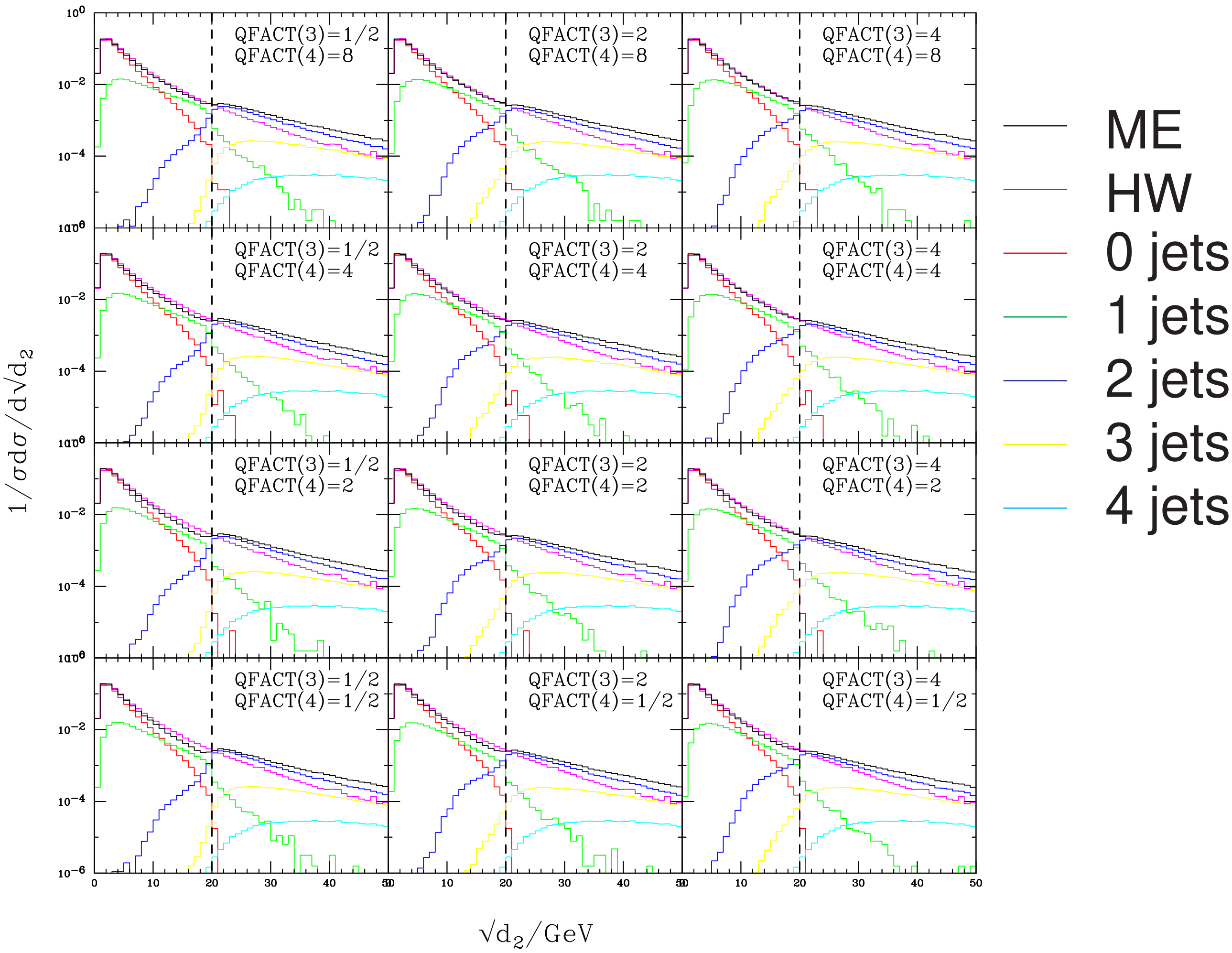
Z Production

- Variation of results with `QFACT(3,4)` from `AFACT(1,2)=1/8`.
- d_1 distribution at the Tevatron



W Production

- Variation of results with `QFACT(3,4)` from `AFACT(1,2)=1/8`.
- d_2 distribution at the Tevatron



Hadron Collisions

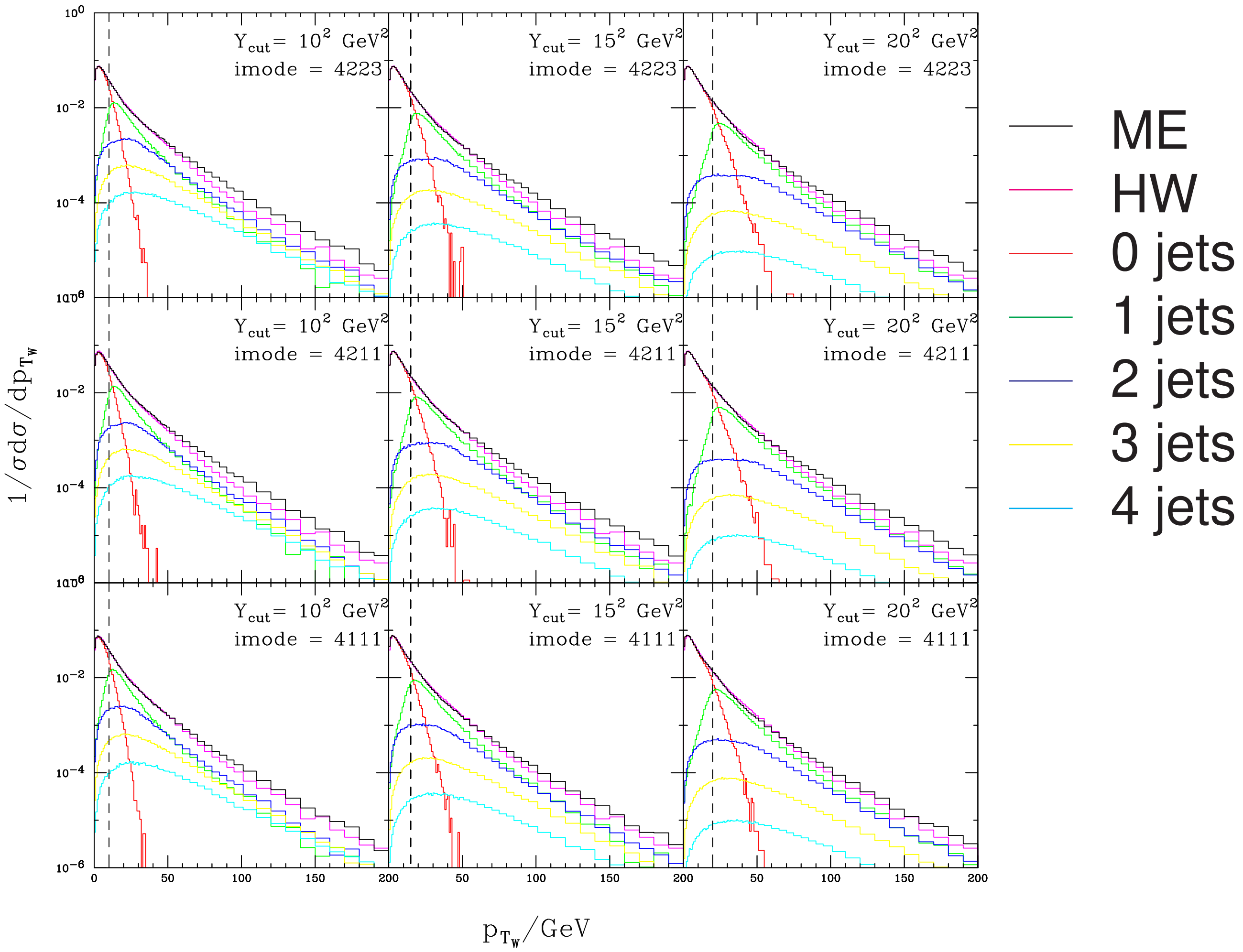
- Hard to get the HERWIG shower to produce more radiation than before below the matching scale.
- Hopefully there is some solution to this?
- Otherwise we will have to use low values of the matching scale.
- *i.e.* a region where the PS is already giving the right answer.
- One other option which helps is to always start the initial state shower at the highest scale in the process.

Hadron Collisions

- Look at the variation with matching scale and algorithm
- Look at three scales
  - 10^2 GeV^2
  - 15^2 GeV^2
  - 20^2 GeV^2
- and three algorithms
  - E-scheme, `IMODE=4111`
  - Covariant E-scheme, `IMODE=4211`
  - Covariant monotonic p_T^2 scheme, `IMODE=4223`.

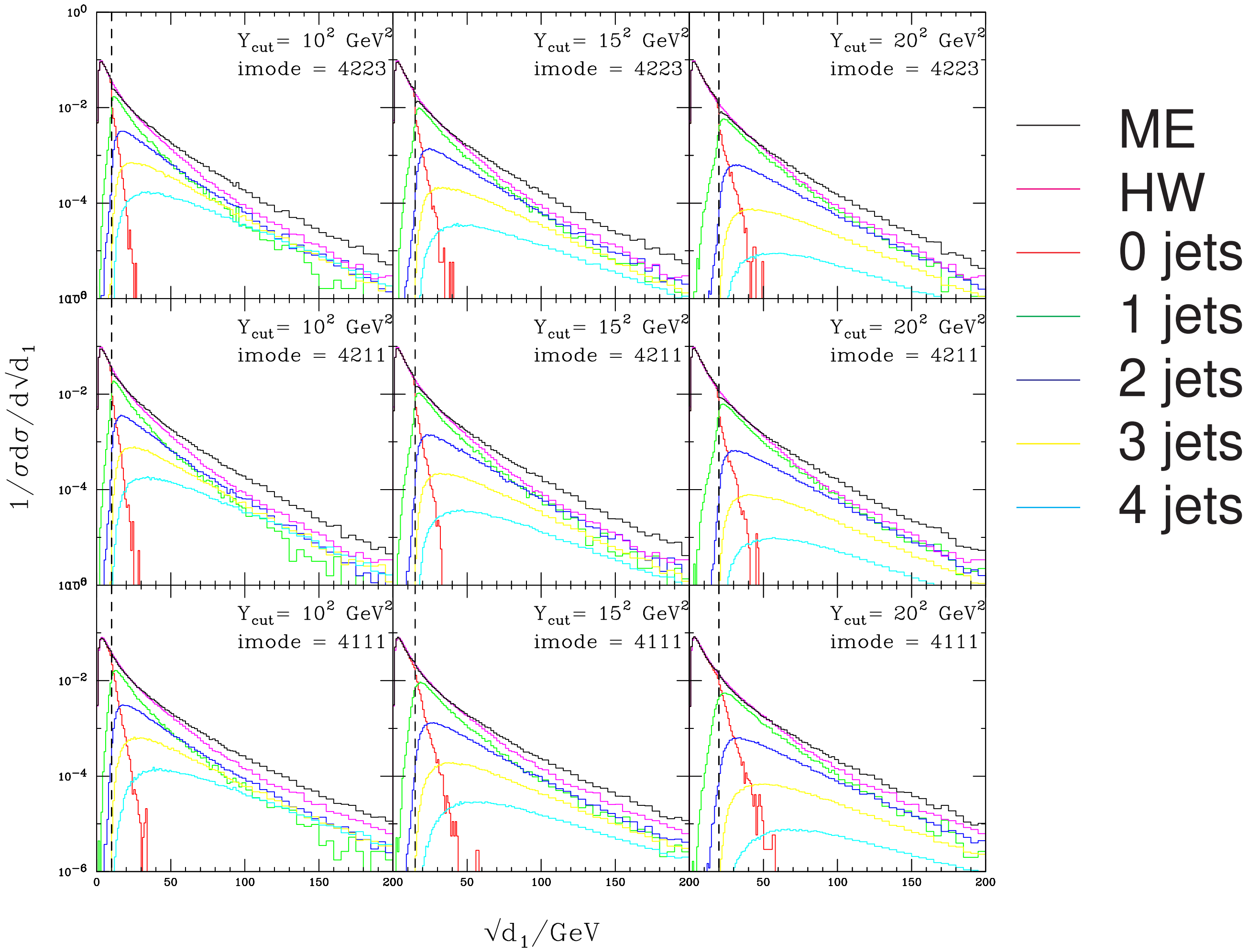
W Production

- `AFACT(1,2)=1/2.`
- p_T of the W at the Tevatron



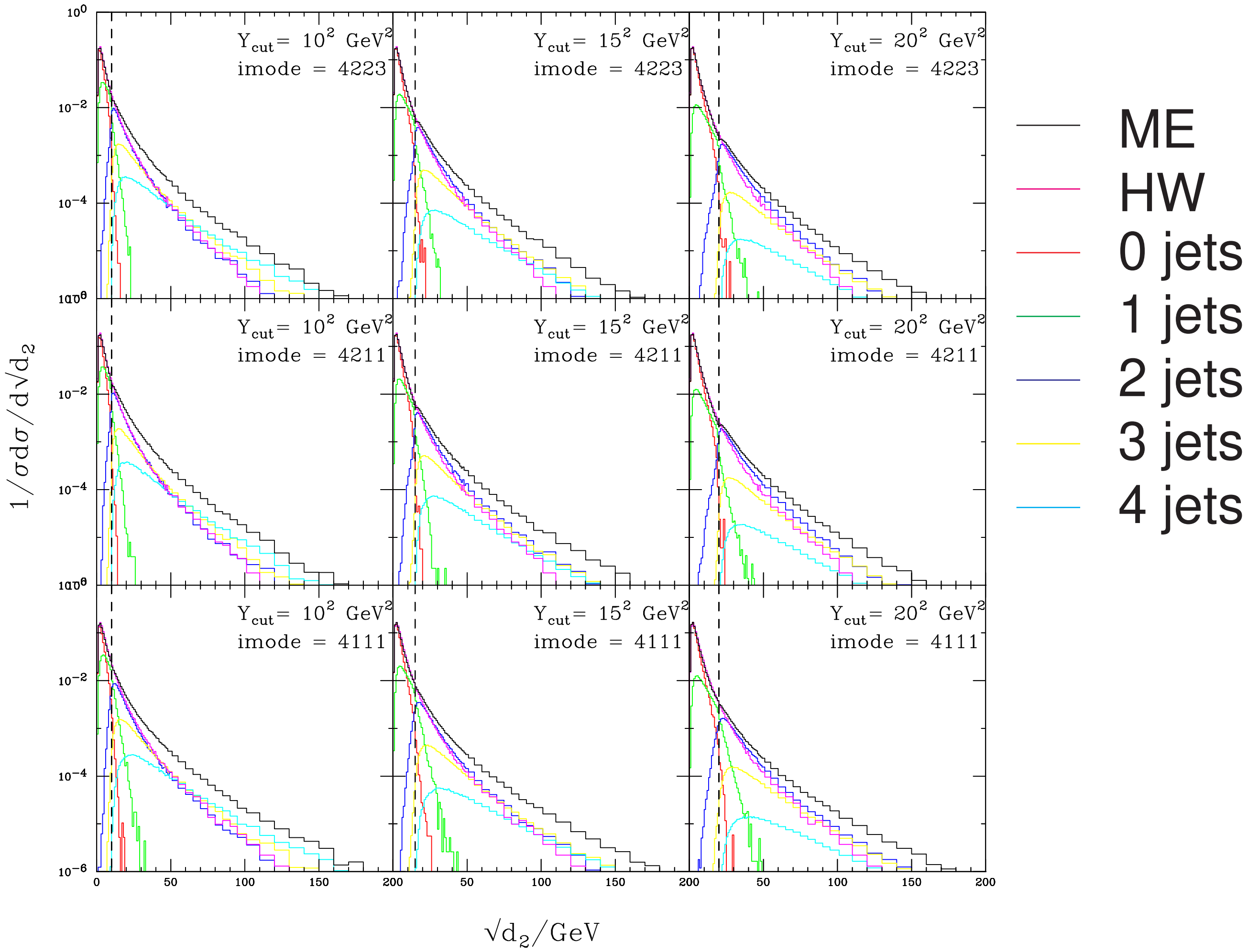
W Production

- `AFACT(1,2)=1/2.`
- d_1 distribution at the Tevatron



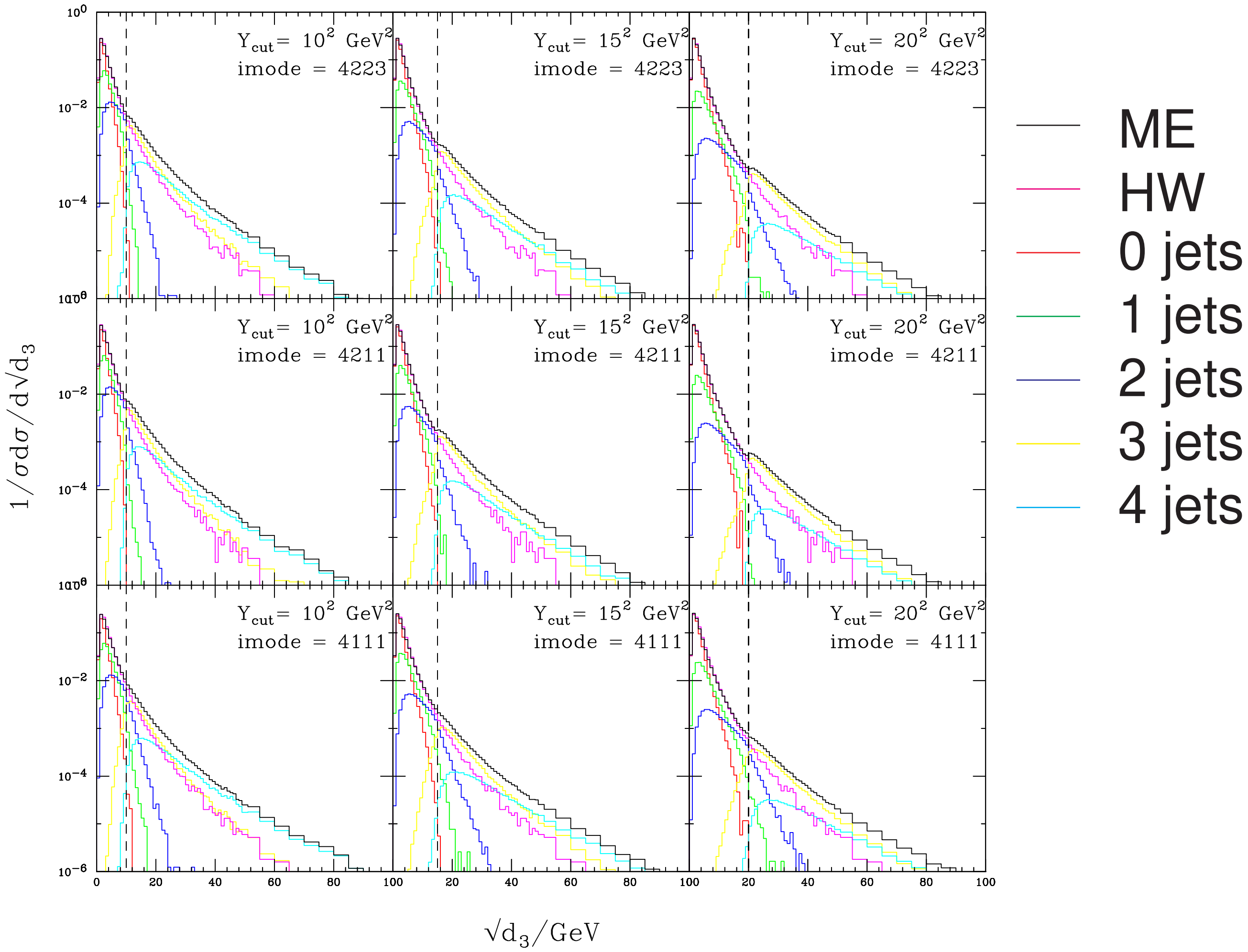
W Production

- AFACT(1,2)=1/2.
- d_2 distribution at the Tevatron



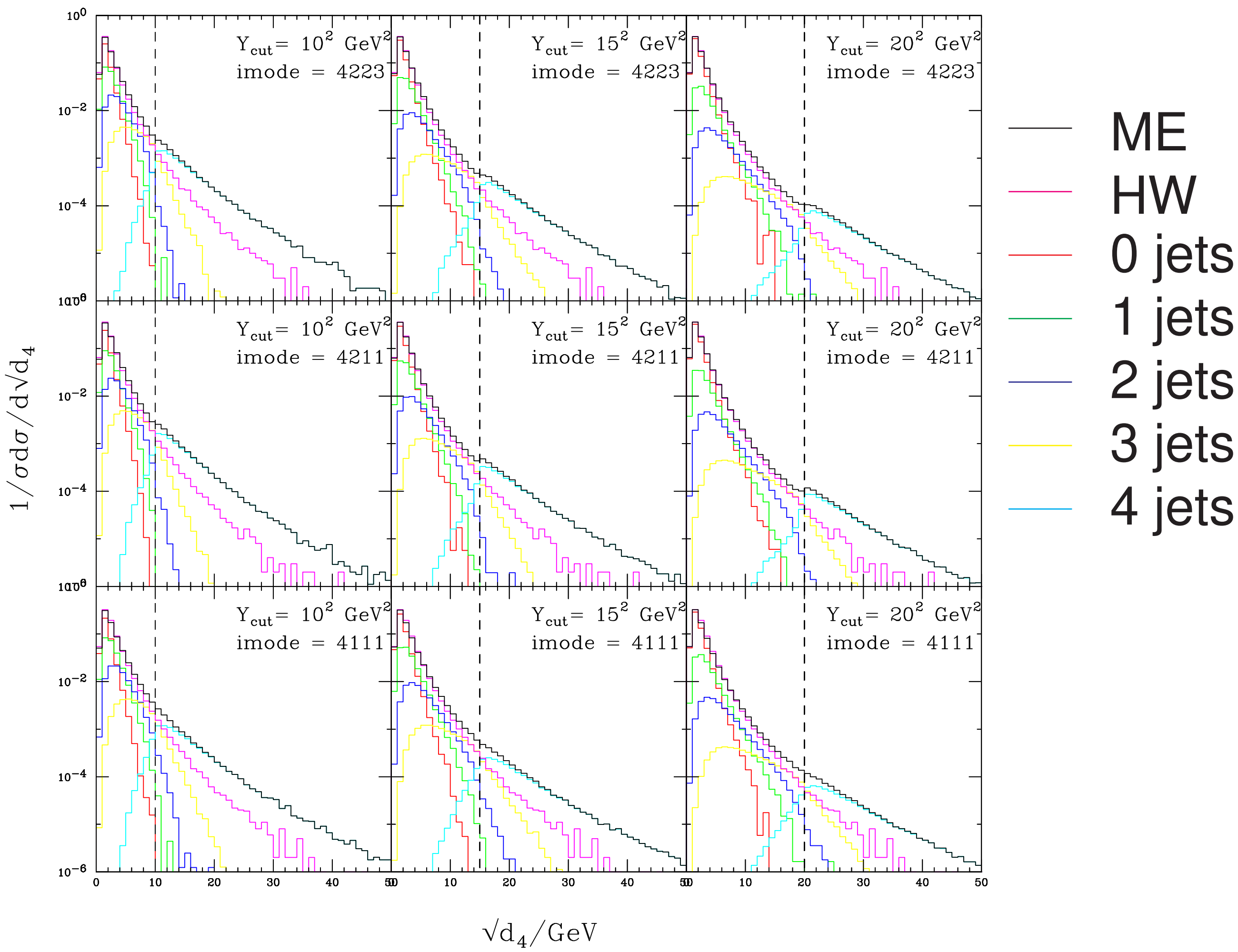
W Production

- AFACT(1,2)=1/2.
- d_3 distribution at the Tevatron



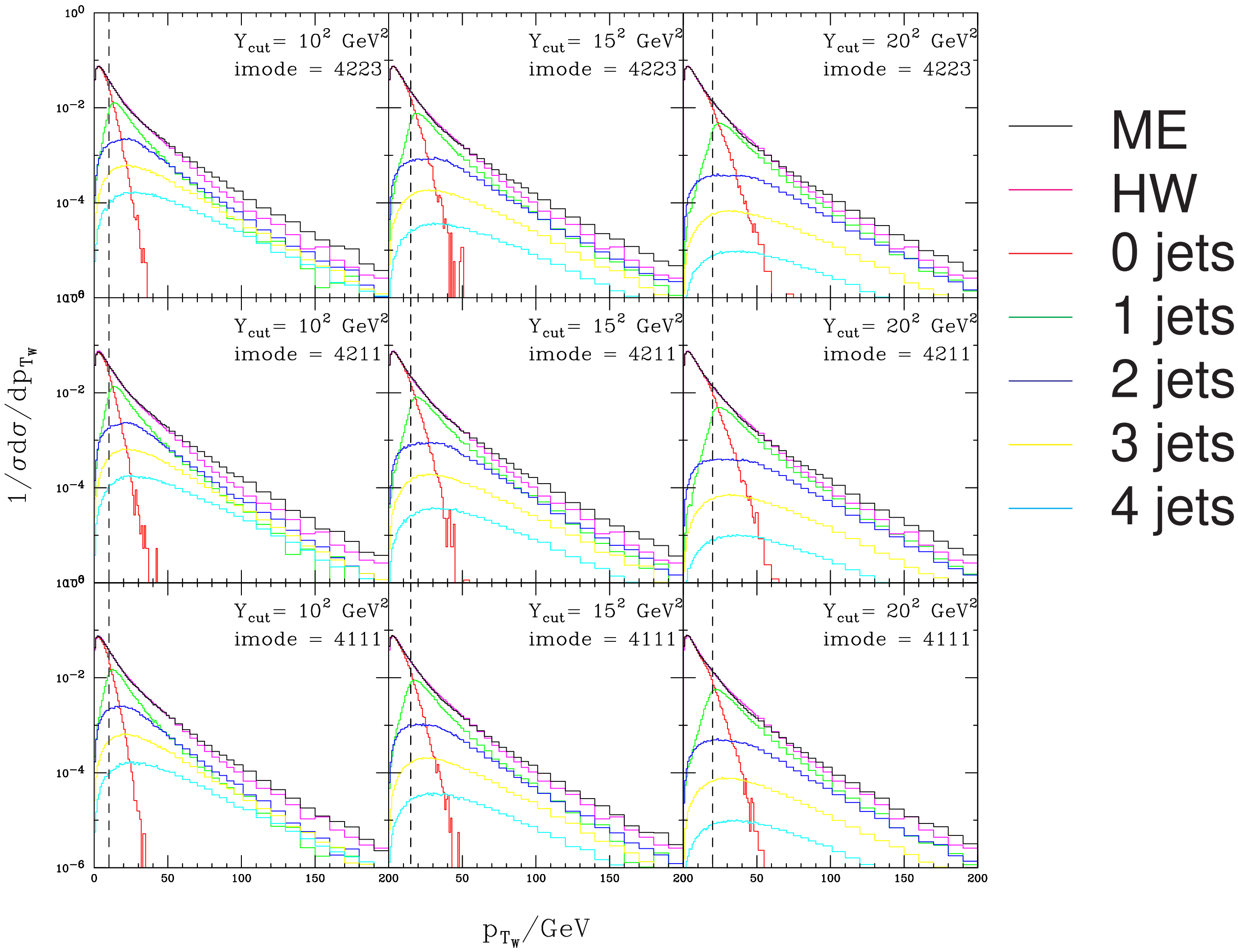
W Production

- `AFACT(1,2)=1/2.`
- d_4 distribution at the Tevatron



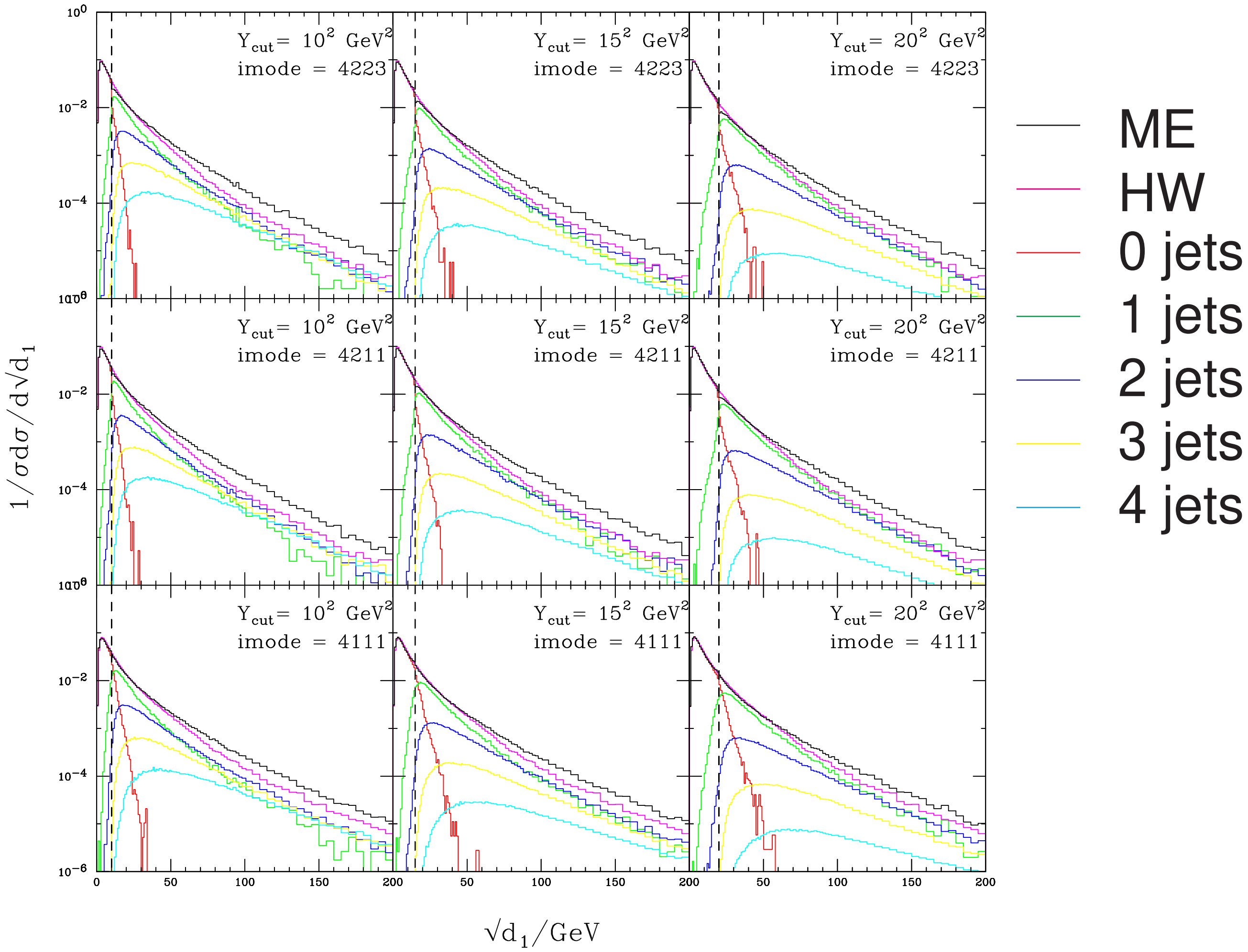
W Production

- `AFACT(1,2)=1/2.`
- p_T of the W at the LHC



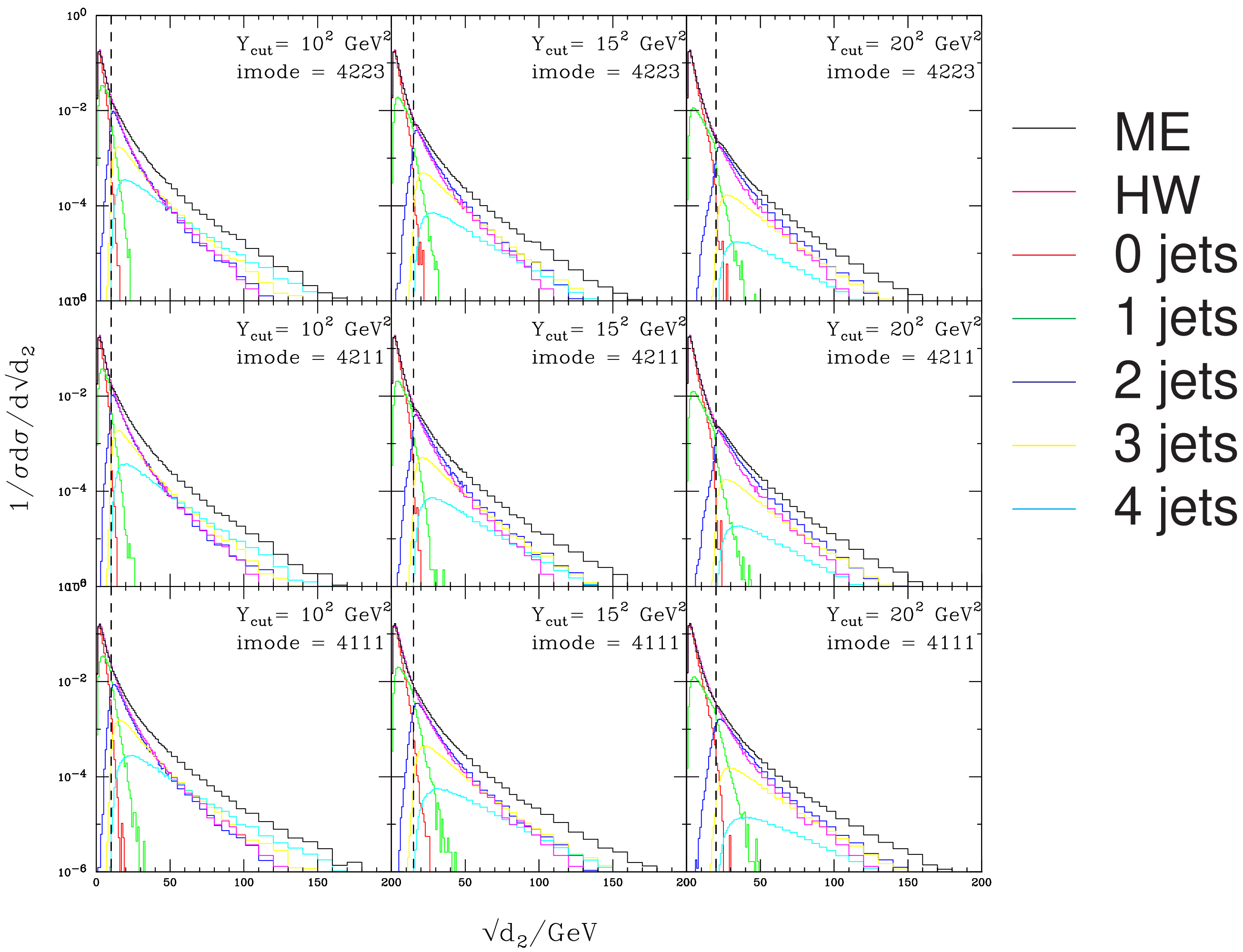
W Production

- AFACT(1,2)=1/2.
- d_1 distribution at the LHC



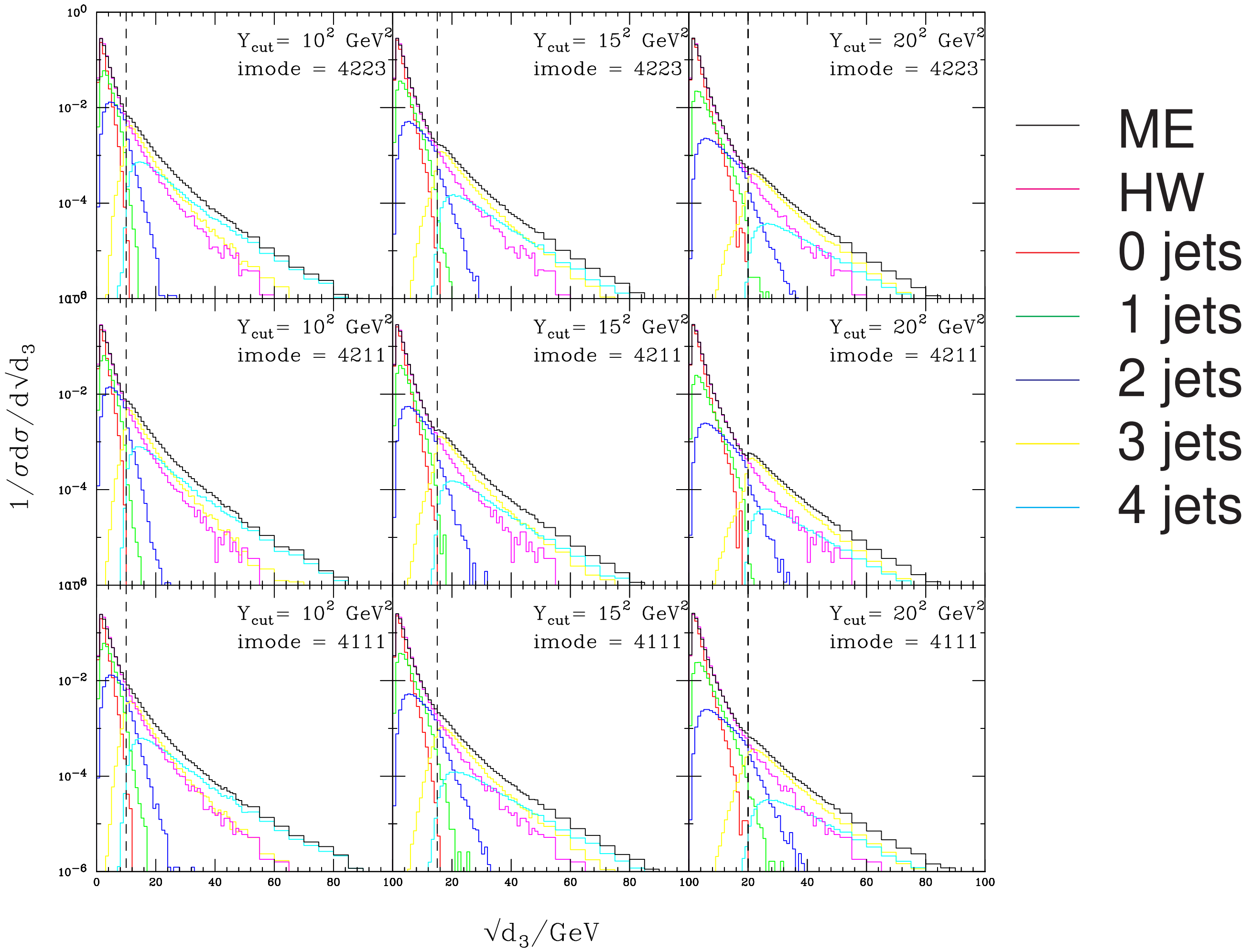
W Production

- AFACT(1,2)=1/2.
- d_2 distribution at the LHC



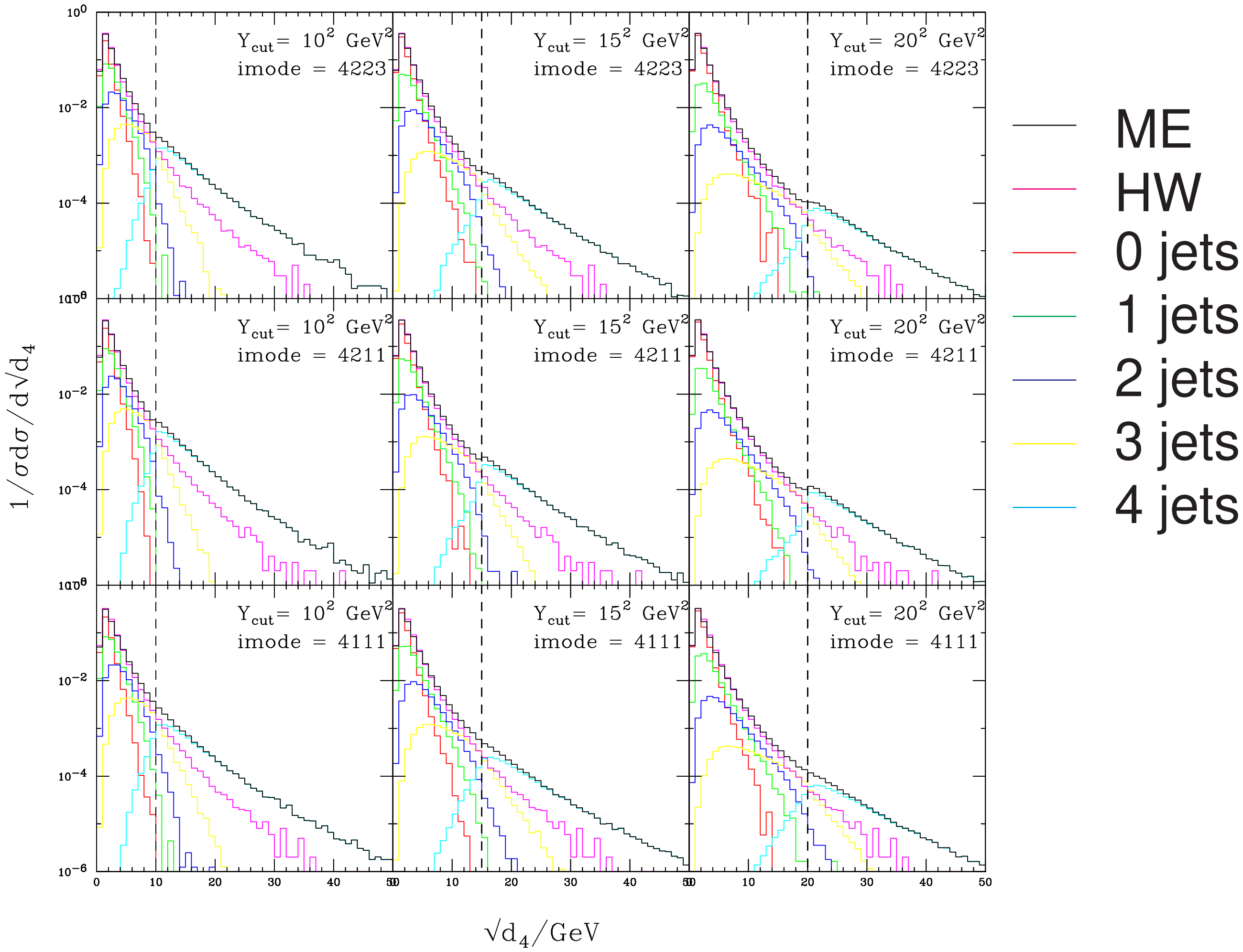
W Production

- AFACT(1,2)=1/2.
- d_3 distribution at the LHC



W Production

- `AFACT(1,2)=1/2.`
- d_4 distribution at the LHC



Conclusions

- I have presented results for the CKKW algorithm with HERWIG.
- We now have good results for e^+e^- collisions
- Still some problems to iron-out in hadron collisions.
- Hopefully the code will be available soon.