Matching ME and PS in the Sherpa framework

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   - Overview of the Algorithm
2. Implementation
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   - Backward cluster scheme (colour flow reconstruction)
   - Initialization of the parton shower
3. Practitioners Tricks
4. Results

Overview of Sherpa

Matrix Element generator `AMEGIC++`

- Calculation of tree-level Matrix elements
- Generation of unweighted events

Parton Shower Module `APACIC++`

- Final State Radiation
- Initial State Radiation

Framework `SHERPA`

- Handling of event generation
- Matching of Parton shower and ME
- Interfaces (ME, PS, Hadronization)

Algorithm

1. Determination of jet rates at an initialization scale
2. Distribute the jet momenta according to the ME
3. Backward cluster the partons
4. Apply a reweighting (Sudakov form factors and coupling constants)
5. Initialization of the parton shower from initial values obtained during step 3

Determination of jet rates at the initialization scale

Cross section for the production of a n-jet event:

$$\sigma_n = \int dx_1\, dx_2\, f_1(x_1, Q^2)\, f_2(x_2, Q^2)\, \sigma(x_1\, x_2\, E_{\mathrm{cms}}^2)\Big|_{y_{ij} > y_{\mathrm{cut}}}$$

Jet measure : covariant E-scheme

$$y_{ij} = \frac{\min(p_{\perp i}^2, p_{\perp j}^2) \cdot R_{ij}}{E_{\mathrm{cms}}^2} \qquad \text{or} \qquad y_{\mathrm{B}j} = \frac{p_{\perp j}^2}{E_{\mathrm{cms}}^2}$$

$$R_{ij} = 2\left[\cosh(\eta_i - \eta_j) - \cos(\theta_i - \theta_j)\right]$$

- strong coupling α_S entering the ME fixed at the jet scale t_{jet}
- PDF determined at the hard scale Q^2

Initialization jet rates given by

$$j_n = \frac{\sigma_i}{\sum_i \sigma_i}$$

Note, these jet rates are modified by the Sudakov rejection.

Backward Clustering

Aim: determine hard 2 to 2 process, and equivalent PS history

1. possible clusterings are given by all possible Feynman diagrams (`AMEGIC++`)
2. choose the pair of partons with minimum y_{ij}
   (in a frame where both incoming are aligned with the z-axis)
3. favor clusterings with the beam where $p_i^z \cdot p_j^z > 0$
4. repeat all steps until 2 to 2 process is reached

Sudakov rejection weights

for hadron collisions given by prescription by F. Krauss

1. for every reconstructed splitting of one parton into two

$$\mathcal{W}_{\text{corr.}} = \frac{\Delta_j(t_{\text{jet}}, t_{\text{prod}})}{\Delta_j(t_{\text{jet}}, t_{\text{dec}})} \cdot \frac{\alpha_s(t_{\text{dec}})}{\alpha_s(t_{\text{jet}})}$$

2. for each outgoing particle

$$\mathcal{W}_{\text{corr.}} = \Delta_j(t_{\text{jet}}, t_{\text{prod}})$$

the scales are given by

$$t = y_{ij} \cdot E^2_{\text{cms}}$$

but see practitioners tricks

Initialization of the parton shower

1. Colour flow is determined on the level of the hard $2 \to 2$ matrix element (as obtained by the Backward Clustering)
2. Colours of other partons are fixed by the shower procedure
3. Starting scale of the parton shower is given by the virtuality of the production parton

$$t_{\rm start} = p^2_{\rm prod}$$

4. Angular constraints are derived from angle to colour partner

Veto on every jet with $p^2_\perp > p^2_{\perp\,\rm ini} = y_{\rm cut} \cdot E^2_{\rm cms}$!

Practitioners Tricks

1. Using the freedom in Sudakov form factors and α_S

$$\mathcal{W}_{\mathrm{corr.}} = \frac{\Delta_j(t_{\mathrm{jet}}, t_{\mathrm{prod}})}{\Delta_j(t_{\mathrm{jet}}, t_{\mathrm{dec}})} \cdot \frac{\alpha_s(d_{\mathrm{dec}})}{\alpha_s(d_{\mathrm{jet}})}$$

   the scales are given by

$$d = y_{ij} \cdot E_{\mathrm{cms}}^2$$

$$t = y_{ij} \cdot E_{\mathrm{cms}}^2$$

   running of α_S at leading order

   PDF set used : MRST99

Practitioners Tricks

2. Modified treatment of events with the highest number of jets in the ME

    - Outgoing partons do not get an Sudakov weight
    - No veto on hard jets

3. Exploit that $p_\perp^2$ is only approximated

    - Multiply y_{cut} in jet veto by $4/3$

Results

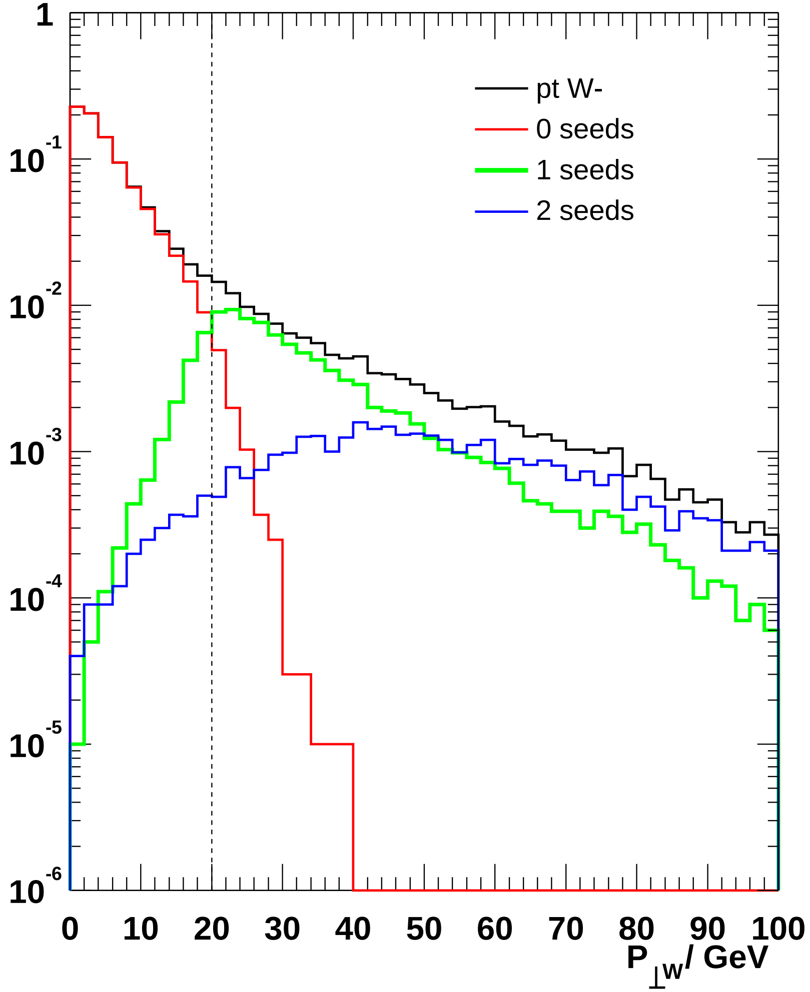
Process:

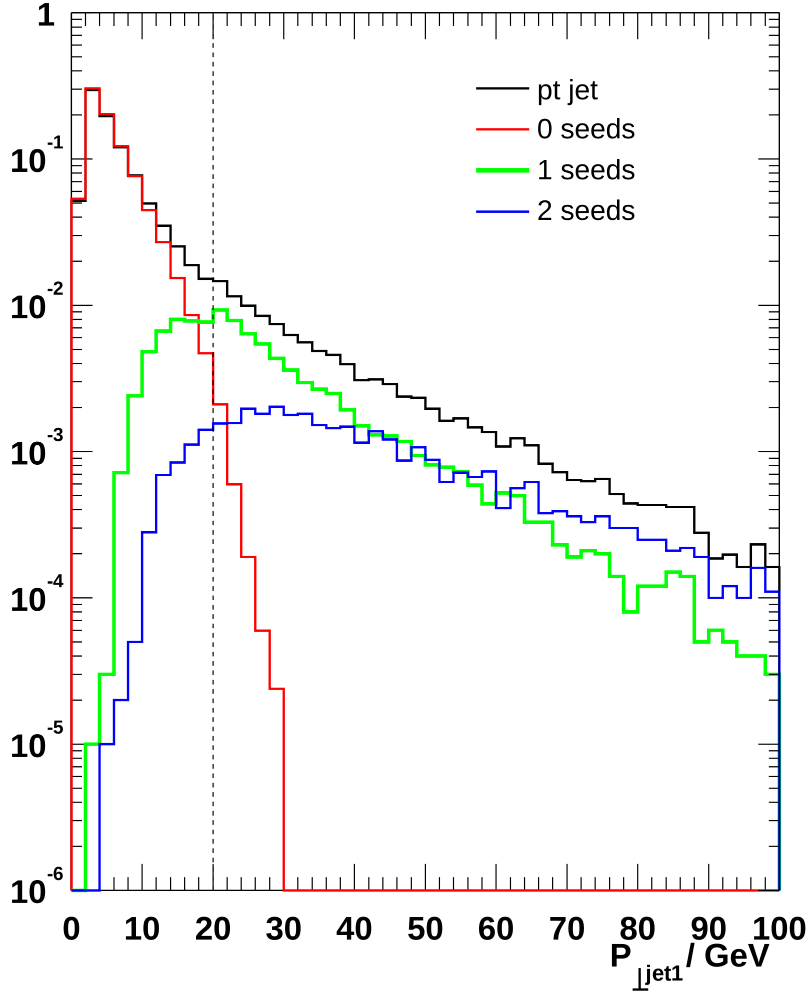
W Production at Tevatron

Variables

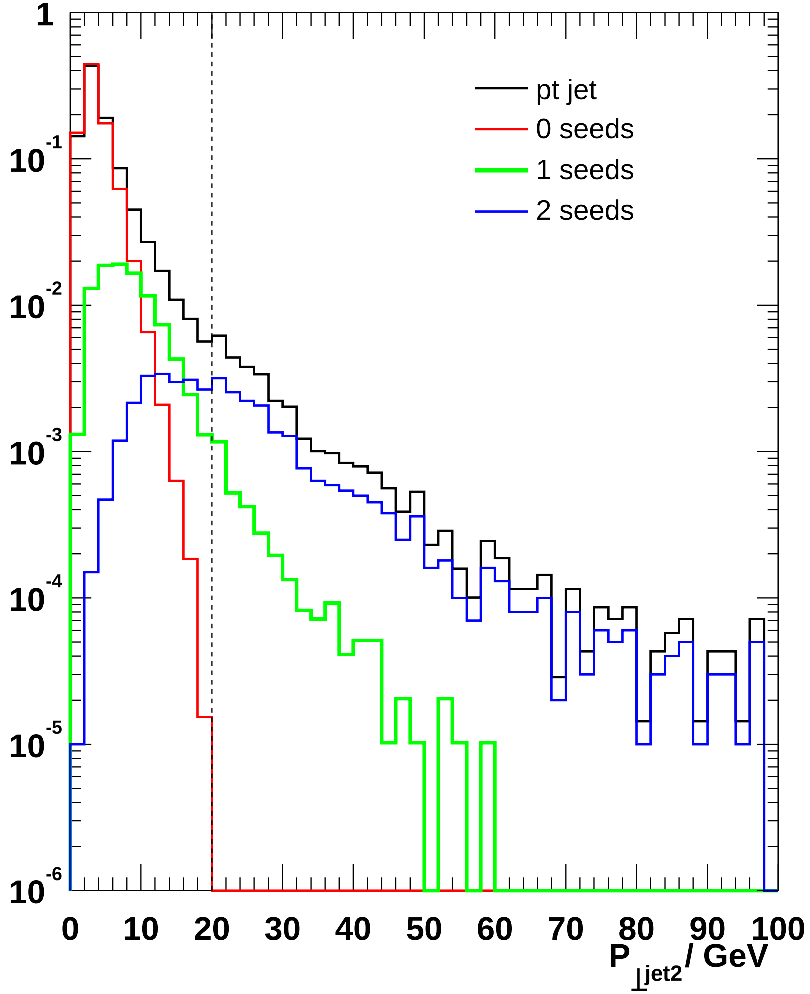
- p_T distribution of the W boson
- p_T distribution of the hardest jet
- differential jet rates

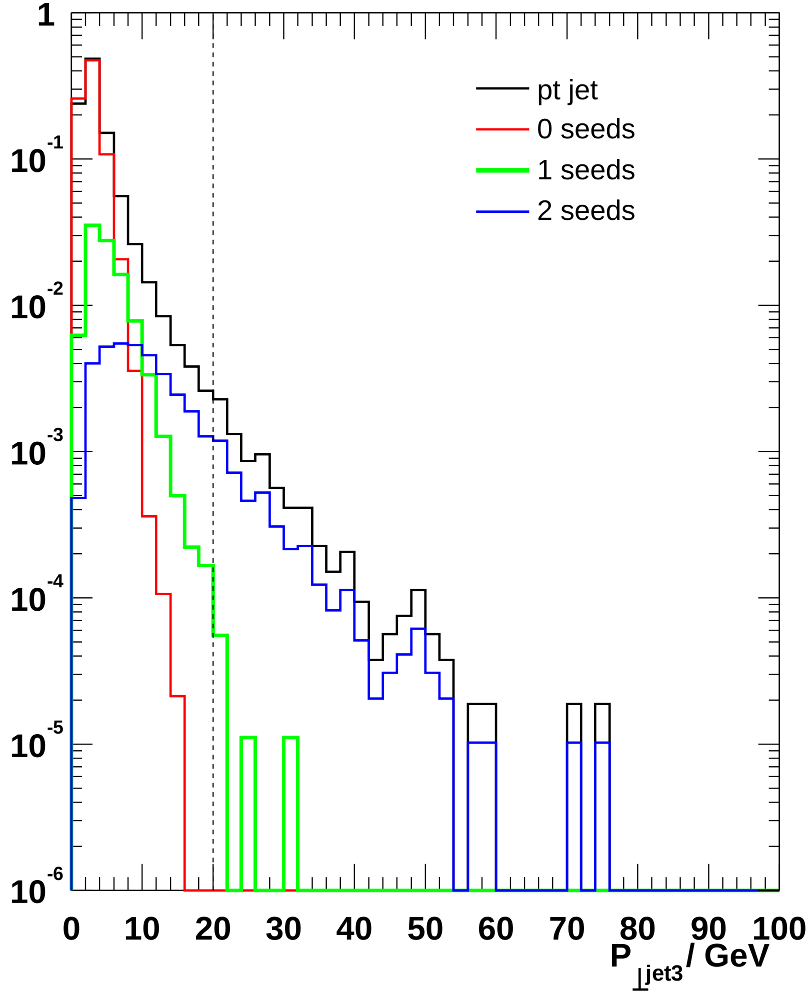
W Production at Tevatron





W Production at Tevatron





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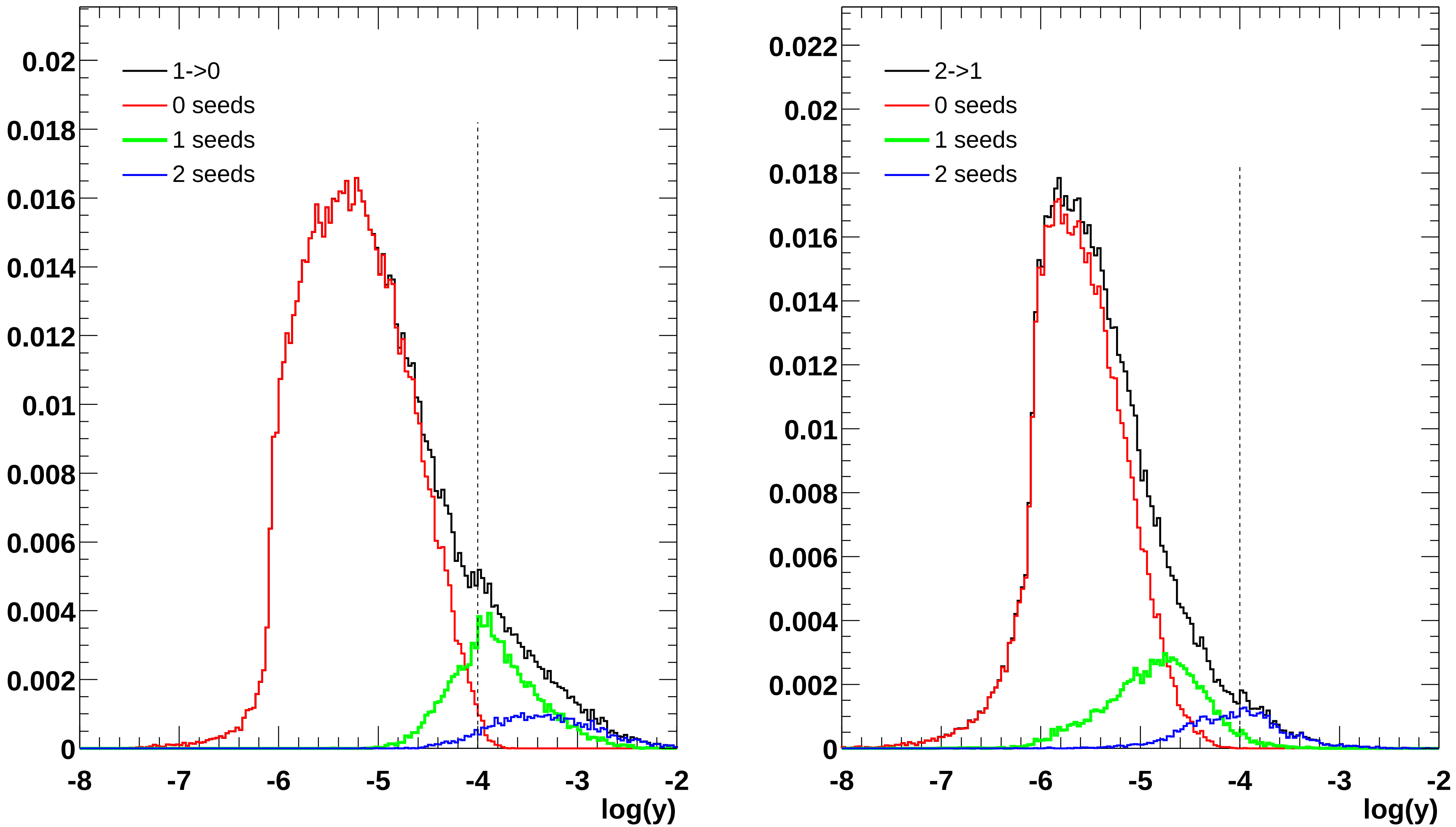

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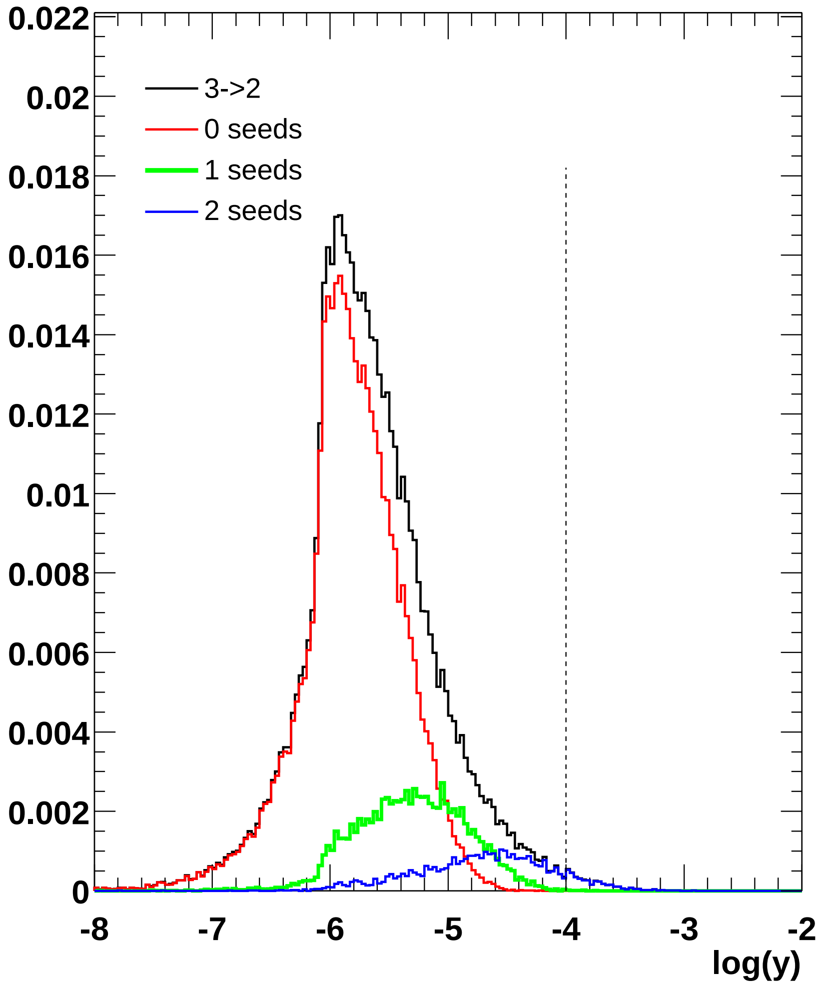

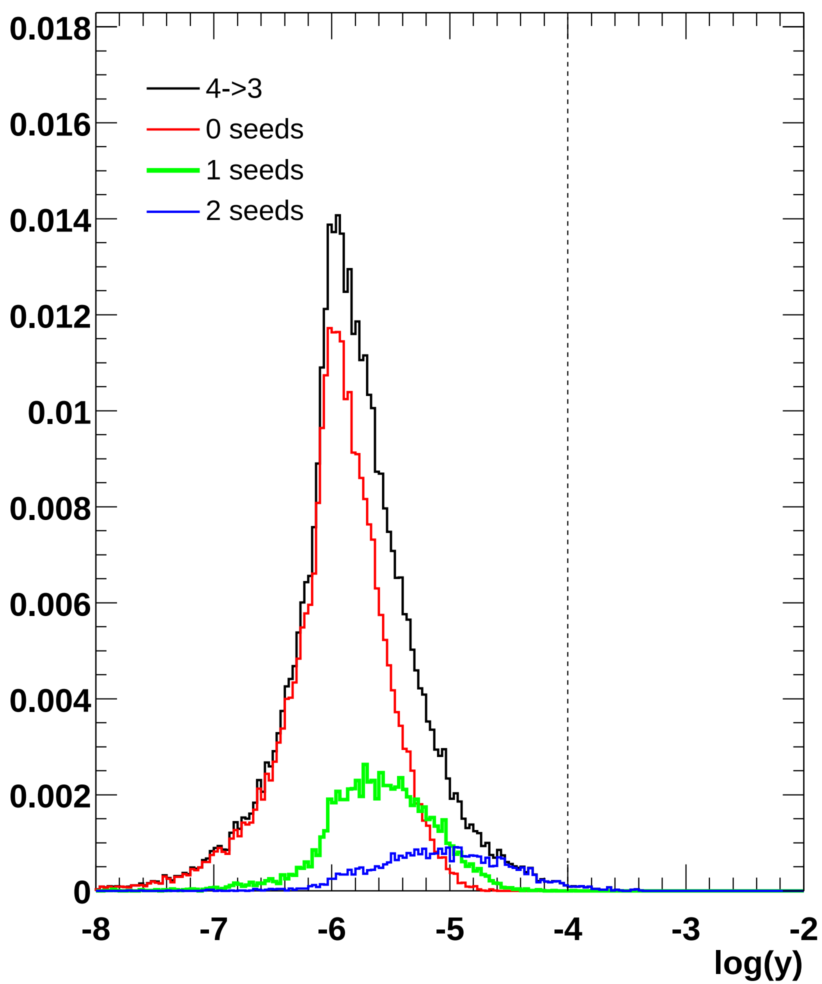

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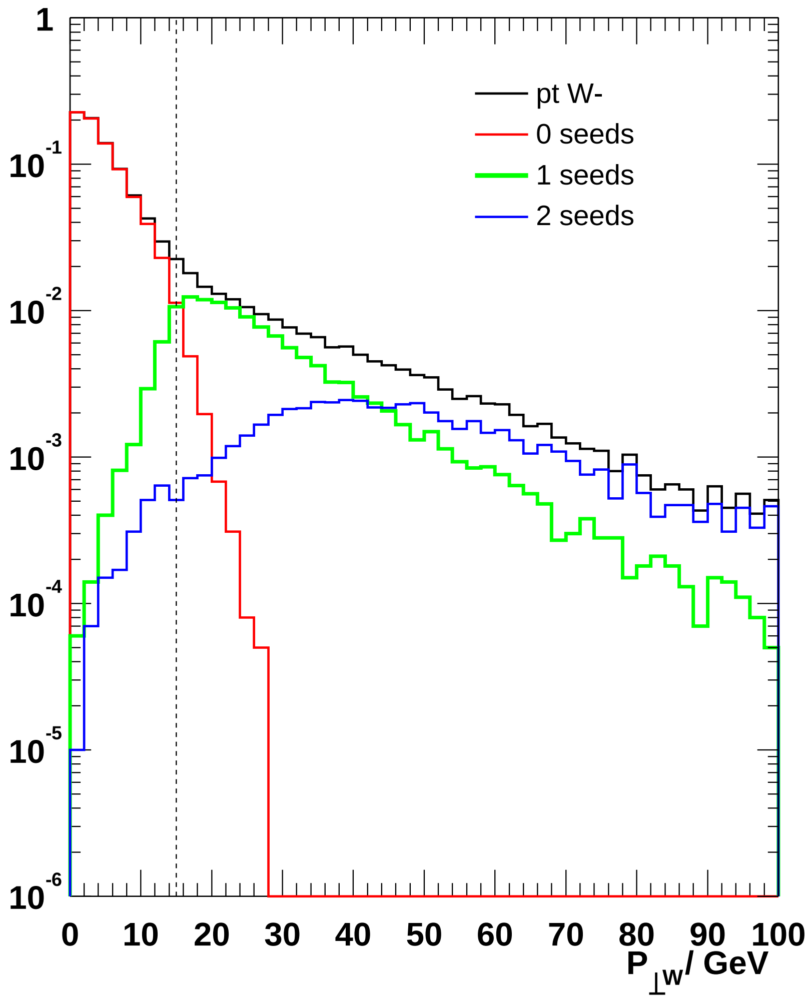

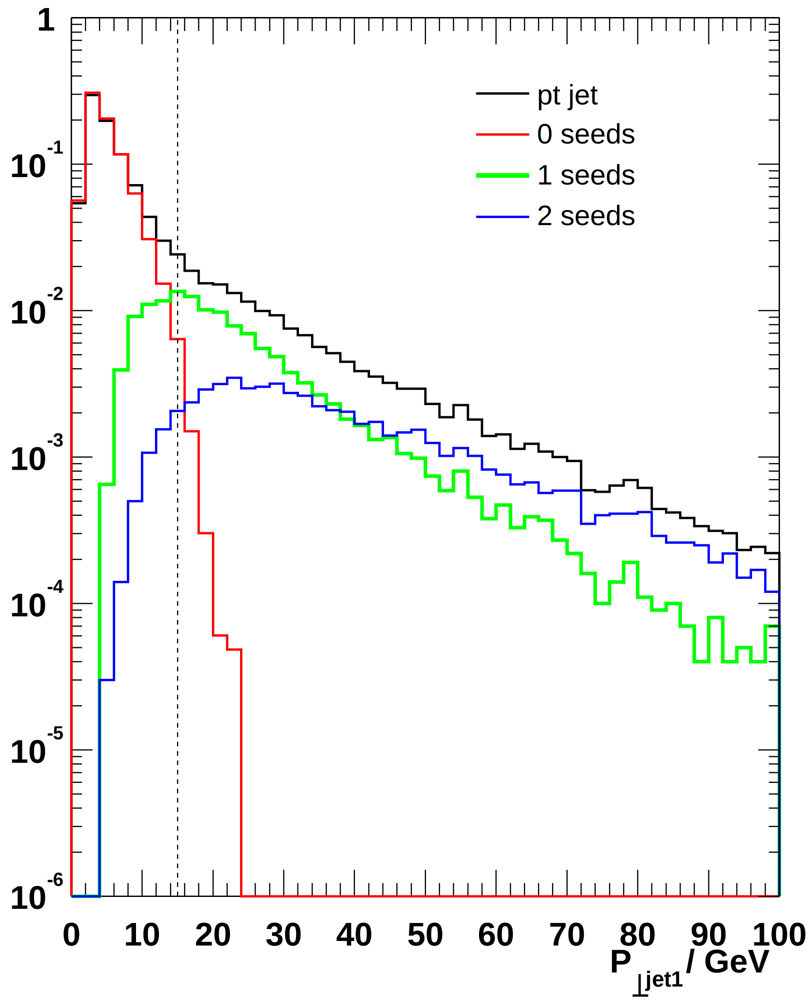

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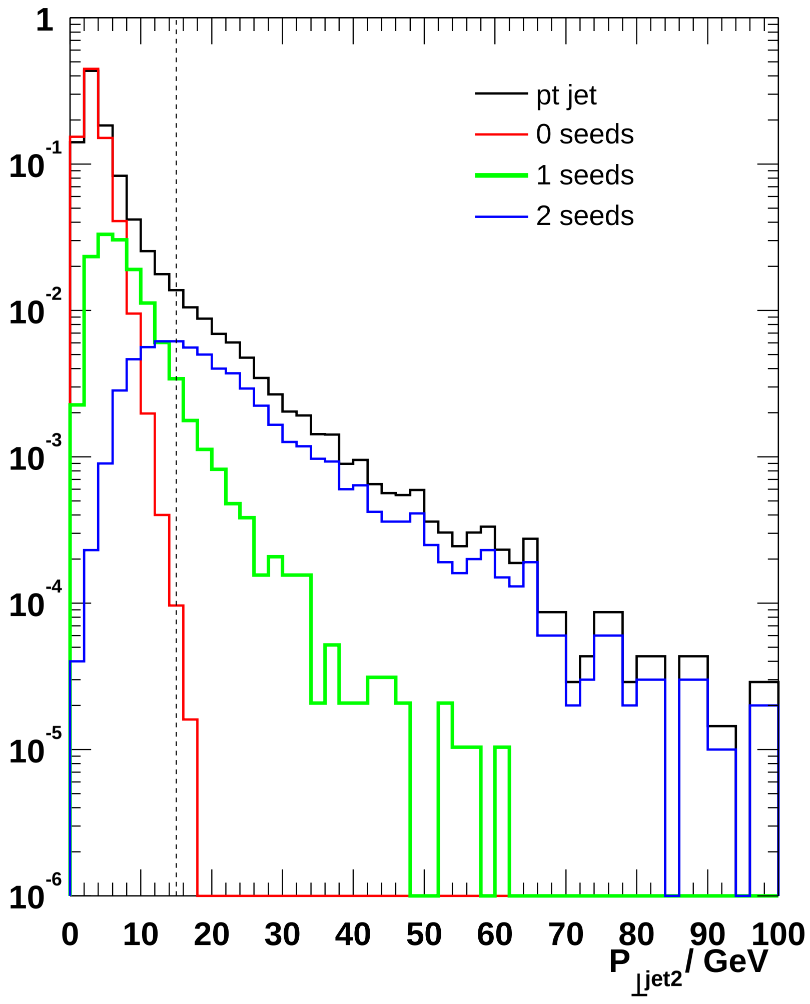

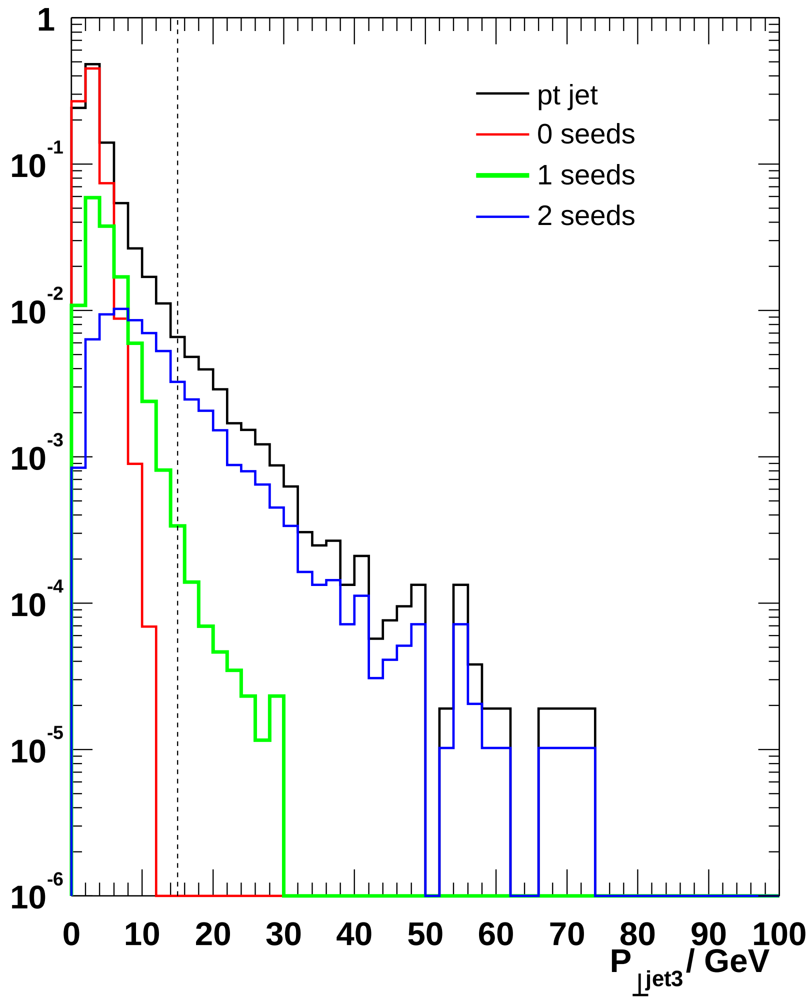

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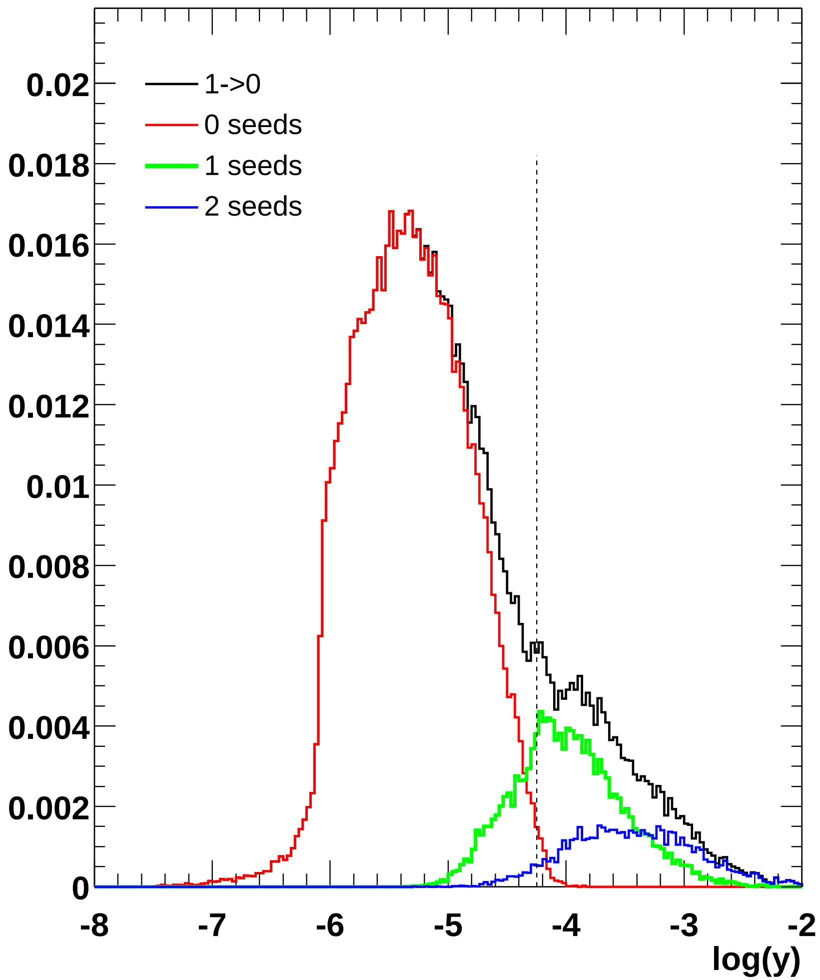

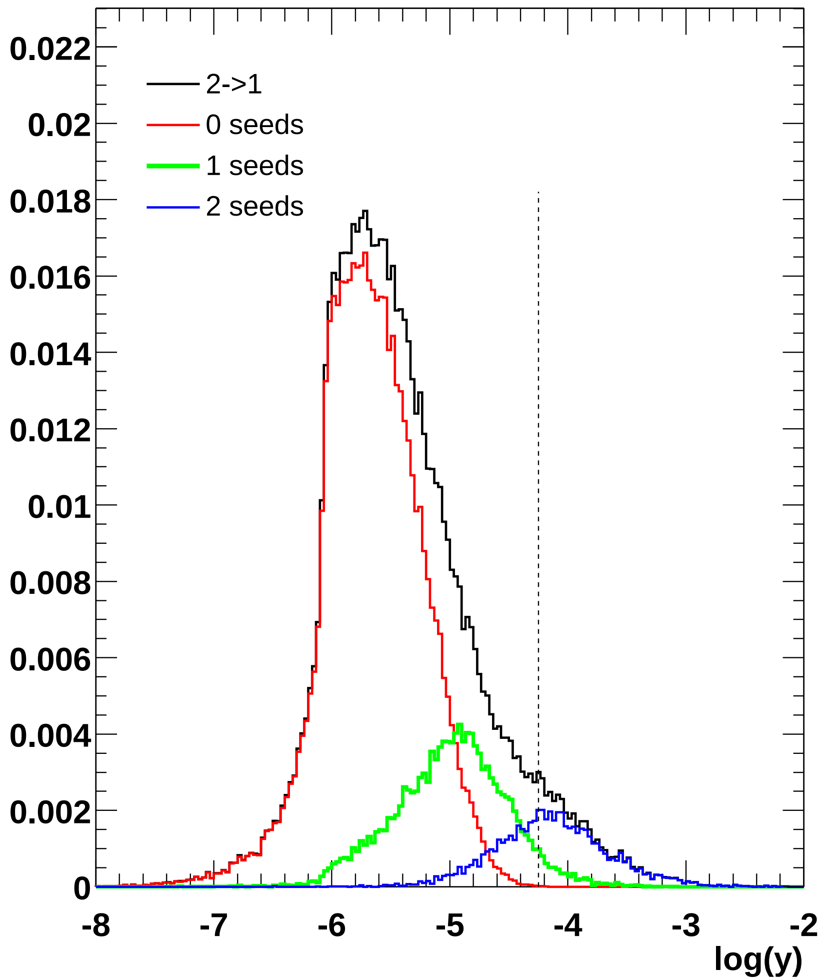

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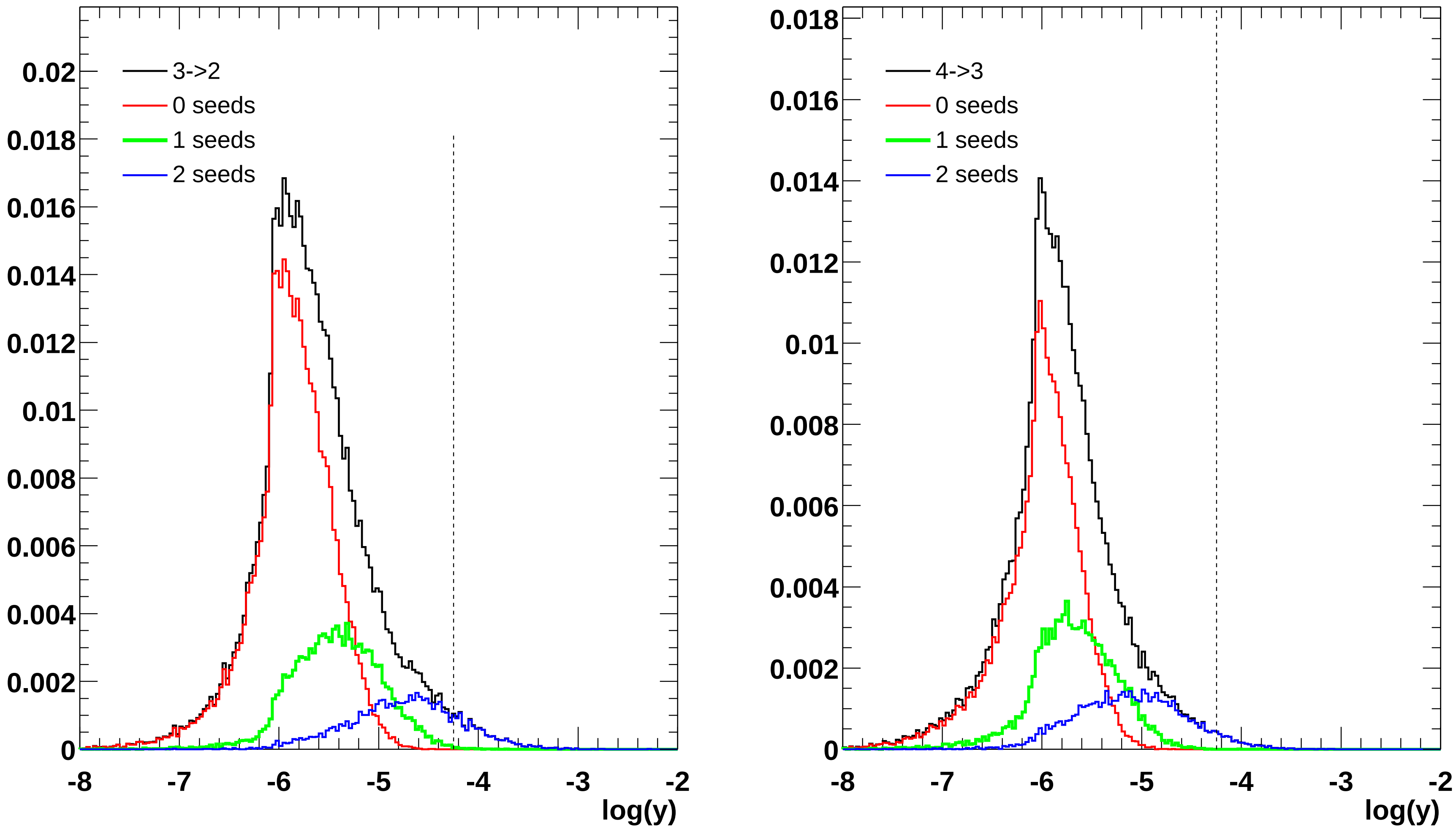

Conclusion

There is much to do!

Aim for the Workshop:

- Discussions with colleagues from PYTHIA and HERWIG
- Comparisons of different implementations for the LHC