# JIMMY 4.01 and HERWIG 6.505

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- Limitations of the old JIMMY
- Approximations in the new version
- Some tips on using the new version
- Where to get the new version

# JIMMY's Simple Eikonal Model

- All scatters treated on an equal footing.
- For fixed impact parameter (b) all scatters are independent. Correlations arise via b dependence of overlap.
- Total cross section for events with n scatters of a given type (e.g. type **a**) is calculated from the parton cross sections, the PDF and the eikonal formalism.

$$\sigma_n = \int \mathrm{d}^2 b \, \frac{\left(A(b)\sigma_{\mathrm{a}}\right)^n}{n!} \, \mathrm{e}^{-A(b)\sigma_{\mathrm{a}}},$$

A(b) is the area overlap function

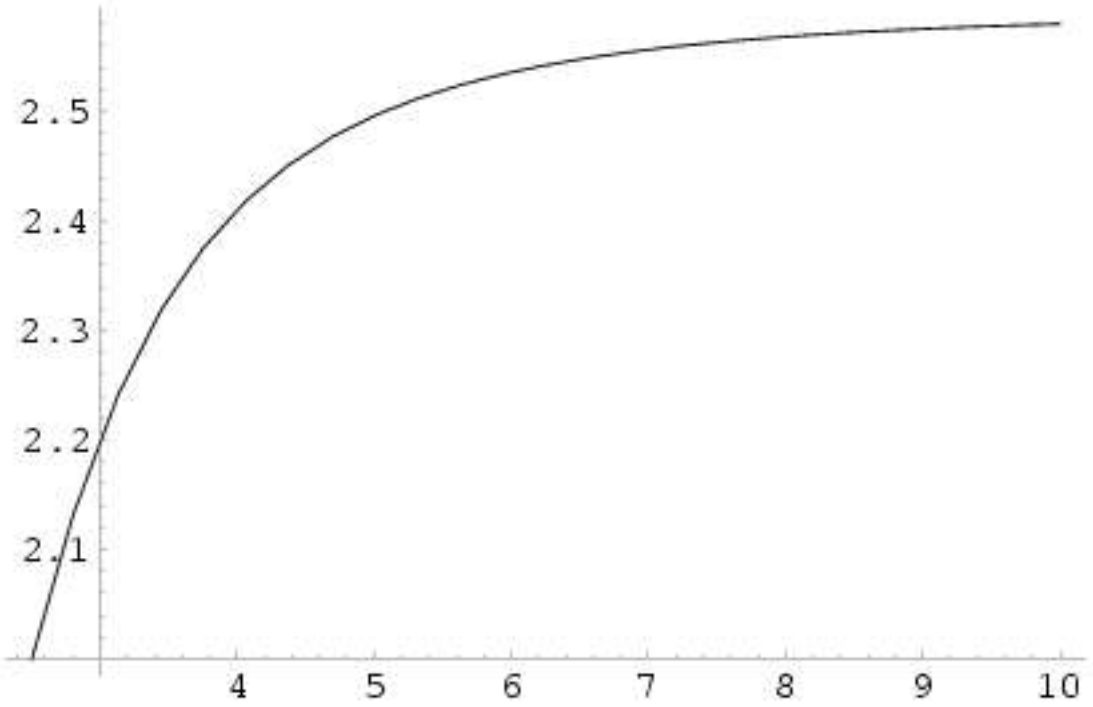



Figure 1: Mean number of low-$p_t$ scatters as a function of the minimum $p_t$ for a trigger scatter in a simple analytical model.

# JIMMY's Simple Eikonal Model

- This is the master formula. It is used to derive the probability that an event has exactly **n** scatters, given that is has at least one. This is pretabulated at the start of a JIMMY run.
- This is used to generate events. Momentum conservation dynamically modifies this during the run (can reduce the amount of multiple scattering).
- The total cross section for events having at least one scatter of type **a** is modified (unitarised) by the program at the end of a run based on the actual number of multiple-scattering events which occurred.

# Practical Problems with JIMMY's Simple Eikonal Model

- Event type **a** is QCD 2->2 scattering (the only implemented process in JIMMY), typically we want to see the effect of low $p_T$ multiple scatters on a high $p_T$ rare event. To get the low $p_T$ multiple scatters, PTMIN must be set low, which is very inefficient.
- Would also like to see the effect of QCD multiple scatters on other rare processes (type **b**). Not possible with the old JIMMY.

# Practical Problems with JIMMY's Simple Eikonal Model

- To calculate the probability of an event having n scatters of type **a** and **m** of type **b**, the formula is:

$$\sigma_{n,m} = \int \mathrm{d}^2 b \, \frac{(A(b)\sigma_{\mathrm{a}})^n}{n!} \, \mathrm{e}^{-A(b)\sigma_{\mathrm{a}}} \, \frac{(A(b)\sigma_{\mathrm{b}})^m}{m!} \, \mathrm{e}^{-A(b)\sigma_{\mathrm{b}}}$$

- Or, if **m** is a subset of **n** (e.g. The higher $p_T$ scatters)

$$\sigma_{n,m} = \int \mathrm{d}^2 b \, \frac{(A(b)\,(\sigma_{\mathrm{a}} - \sigma_{\mathrm{b}}))^{n-m}}{(n-m)!} \, \mathrm{e}^{-A(b)(\sigma_{\mathrm{a}}-\sigma_{\mathrm{b}})} \, \frac{(A(b)\sigma_{\mathrm{b}})^m}{m!} \, \mathrm{e}^{-A(b)\sigma_{\mathrm{b}}}$$

- To tabulate such results at the start requires prior knowledge of the cross section for **b** as well as **a** and is very awkward in the old set up.

# Approximate, approximate...

- In (almost?) all cases of interest, a=QCD 2->2 scattering, and **b** is a much smaller cross section.
- Work in the approximation that the chance of >1 scatter of type **b** is negligible.
- Probability of n scatters of type **a** and at least one of type **b** is:

$$P(n|m \geq 1) = \frac{\int \mathrm{d}^2b \, \frac{(A(b)\sigma_{\mathrm{a}})^n}{n!} \, \mathrm{e}^{-A(b)\sigma_{\mathrm{a}}} \left(1 - \mathrm{e}^{-A(b)\sigma_{\mathrm{b}}}\right)}{\int \mathrm{d}^2b \left(1 - \mathrm{e}^{-A(b)\sigma_{\mathrm{b}}}\right)}, \qquad n \geq 0$$

Since $\sigma_{\mathrm{b}}$ is small, we can expand the exponentials and obtain

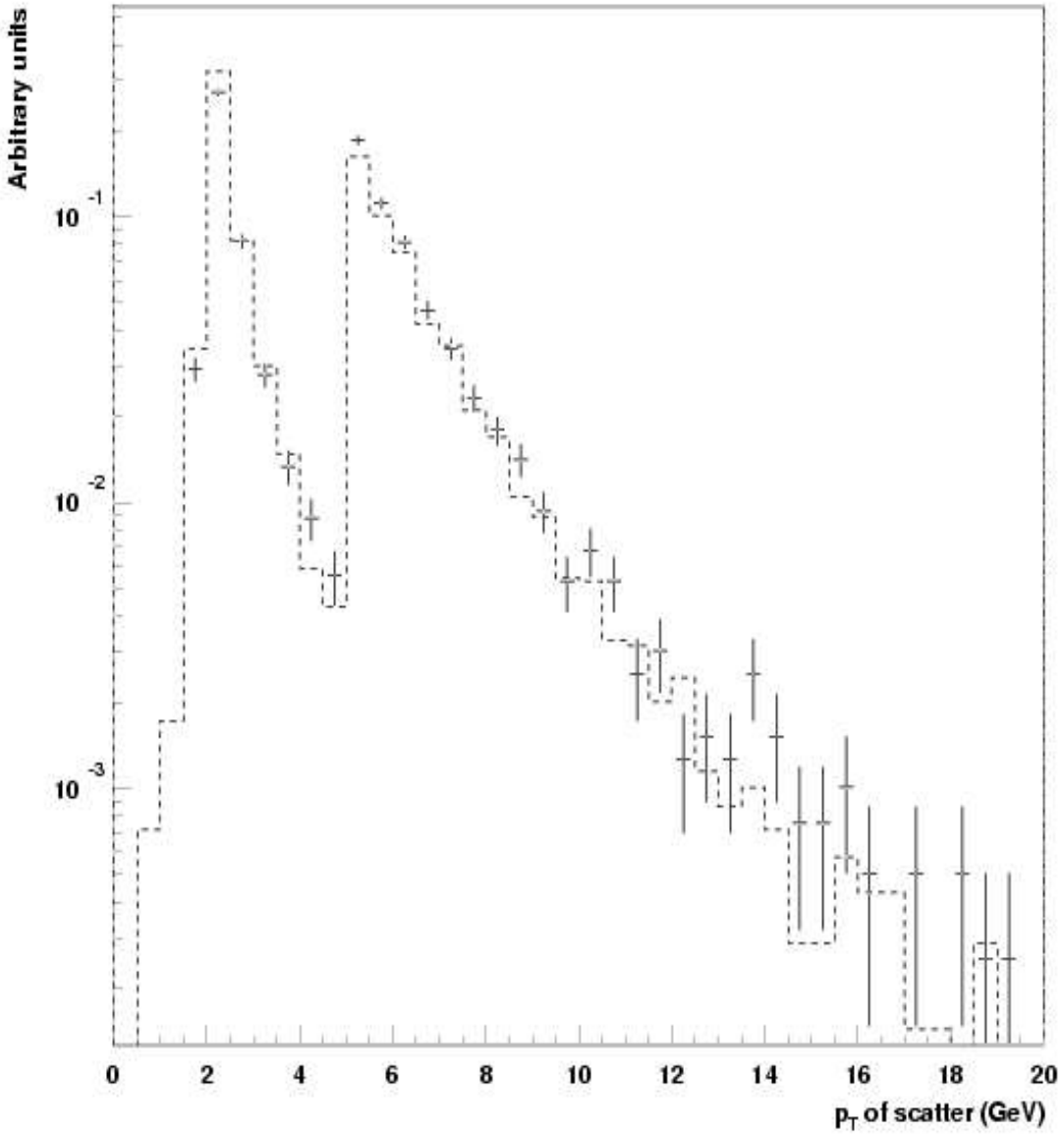
$$P(n|m \geq 1) \approx \int \mathrm{d}^2b \, A(b) \, \frac{(A(b)\sigma_{\mathrm{a}})^n}{n!} \, \mathrm{e}^{-A(b)\sigma_{\mathrm{a}}}, \qquad n \geq 0.$$

# Approximate, approximate...

- For the special case where **b** is a subset of **a**, there is a problem with double counting – scatters of type **a** can produce **b**-type events.
- Fixed by vetoing higher $p_T$ scatters:
  - If a scatter of type a is also of type **b**, reject the **m**$^{th}$ type b scatter with probabilty 1/**m**
- Contunuous at the boundary between **a** and **b**, correct to first order in $\sigma_b$

# Test

- Old “exact” JIMMY (crosses). PTMIN=2 GeV. Plot $p_T$ for all scatters in events with at least one scatter of $p_T$>5 GeV.
- New JIMMY (dashed histo) with PTJIM=2 GeV and PTMIN= 5 GeV.



# How to run it...

- JIMMY underlying event option JMUEO.
- JMUEO=0. Old JIMMY. QCD 2->2 Cross section is Eikonalised, best for “minimum bias” physics ($p_T$>PTMIN)
- JMUEO<>0 (default).
  - 1-> QCD 2->2 with PTMIN<>PTJIM
  - 2-> small cross section “b”. Multiple scatters PT>PTJIM. PTMIN may or may not be relevant, depending on the process b.
- PTJIM and JMUEO (and other JIMMY parameters) are in jimmy.inc
- See http://jimmy.hep.ucl.ac.uk