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Final States in DIPSY

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Low x , Ischia Island 8-13/9 2009

Work done with Gösta Gustafson and Leif Lönnblad.

Introduction

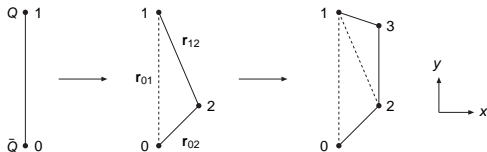
- ▶ Dipoles do very well at inclusive cross sections.
- ▶ Exclusive final states are not as easy.
- ▶ DIPSY is a very detailed initial state dipole evolution model.
- ▶ We are prepared to move on to final states!



Evolution in rapidity

A colour dipole emits a gluon in transverse space with probability

$$\frac{dP}{dy} = \frac{\bar{\alpha}}{2\pi} d^2 r_2 \frac{r_{01}^2}{r_{02}^2 r_{12}^2}$$



Equivalent to LL BFKL.



Interaction

A Born level calculation gives the collision amplitude for a pair of dipoles from different states:

$$f_{ij} = \frac{\alpha_s^2}{2} \ln^2 \left(\frac{r_{13} r_{24}}{r_{14} r_{23}} \right).$$

With the eikonal approximation, the total unitarised probability then becomes

$$t \equiv 1 - e^{-\sum f_{ij}}.$$

Gösta Gustafson will talk more about how to get elastic and diffractive cross sections.



Modifications in DIPSY

Energy conservation

- ▶ Keep track of p_μ for all partons.
- ▶ Small dipoles \leftrightarrow high p_T .
- ▶ Gives dynamic cutoff for small emissions.

Non-linear $2 \rightarrow 2$ swing:

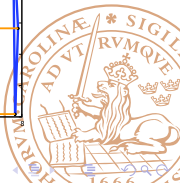
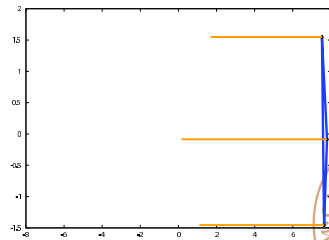
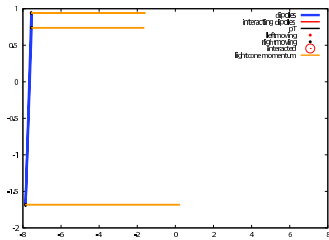
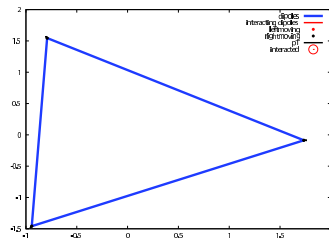
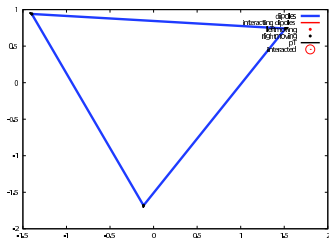
- ▶ Saturation in evolution.

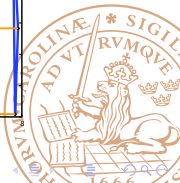
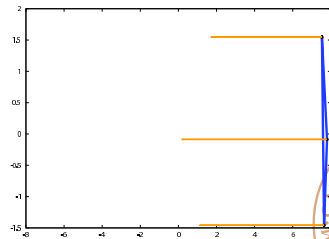
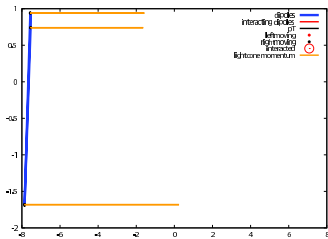
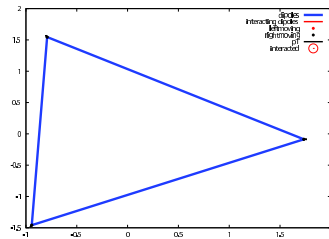
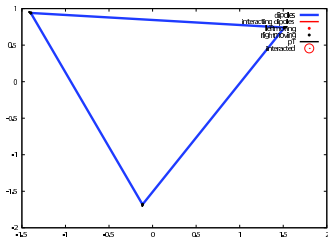


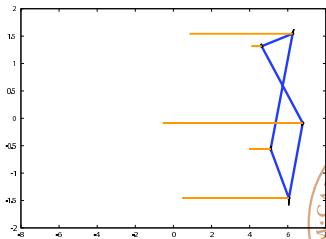
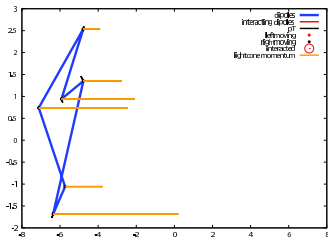
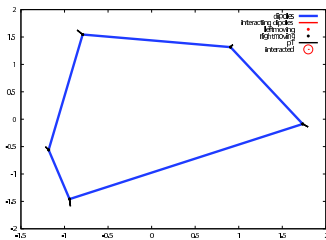
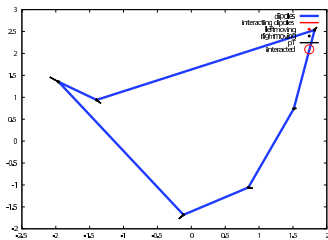
Confinement

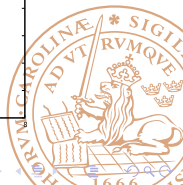
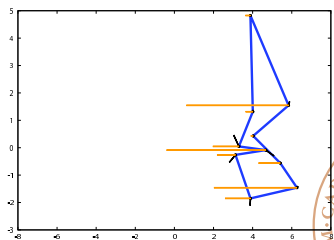
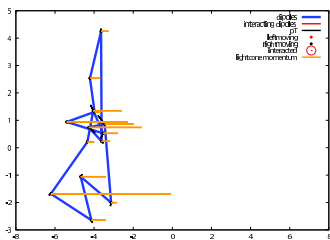
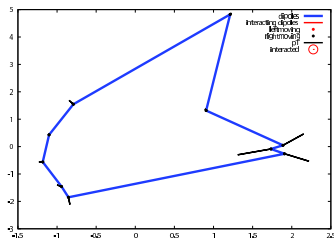
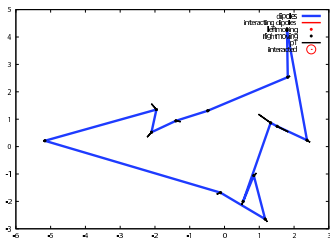
- ▶ Suppression of too large dipoles.

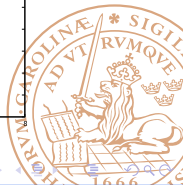
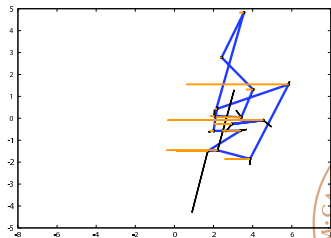
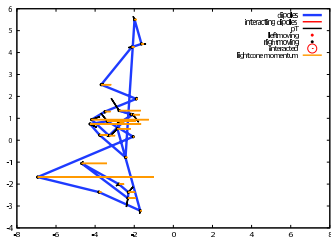
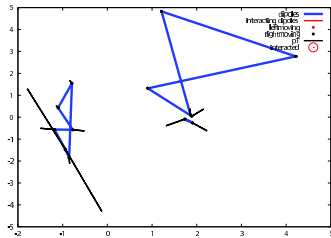
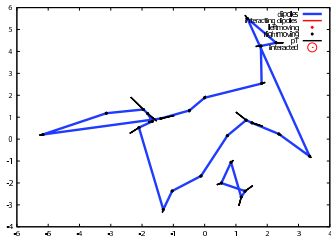


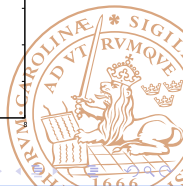
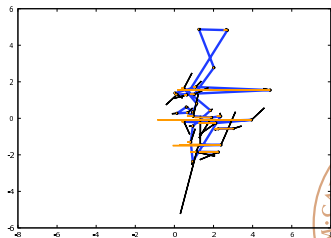
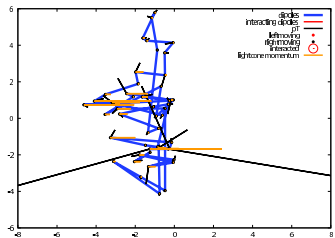
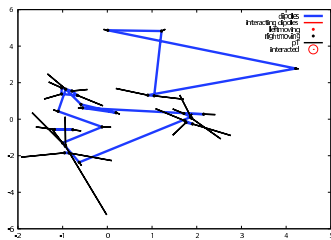
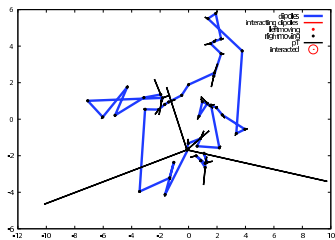






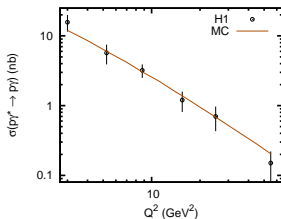
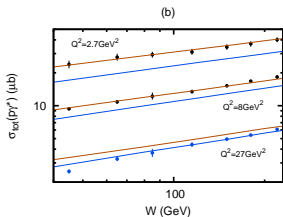
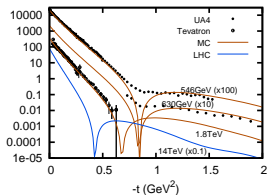
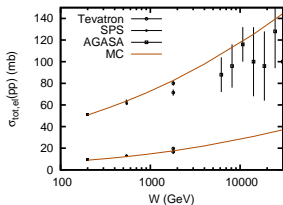






Some sample results

pp and γ^*p : total, elastic and diffractive cross section.



Final States

Want to use all the information about the particles in the generated initial states.

Can not take them as they are though.

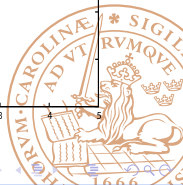
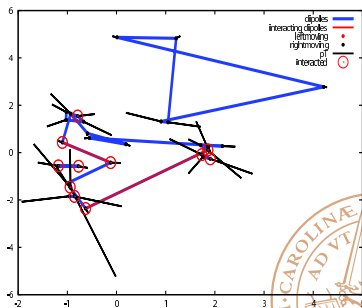
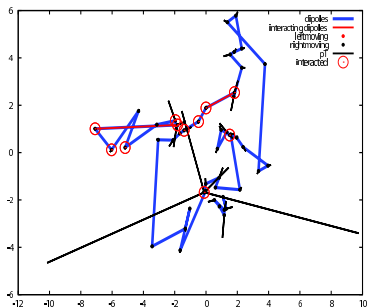
More complicated than expected, but we are getting close now.



Selecting Interactions

Eikonal approximation \rightarrow Poissonian distribution.

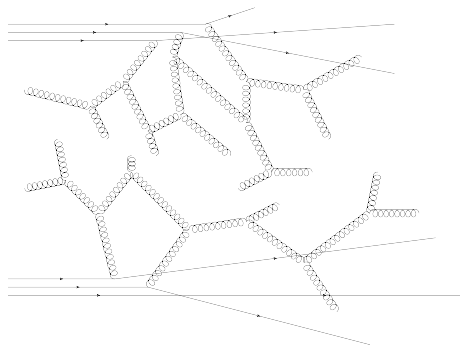
Can use f_{ij} to get scattering probabilities for each individual dipole pair.



Virtual Partons

Emissions that do not interact cannot get on shell since they are ordered in virtuality.

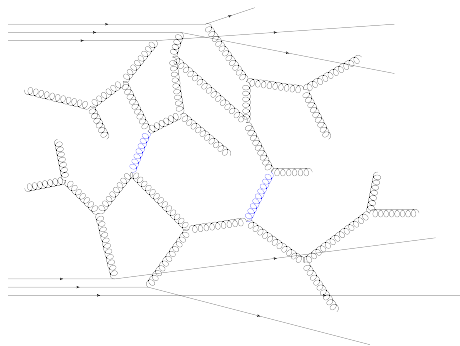
Must be virtual emissions, should be reabsorbed.



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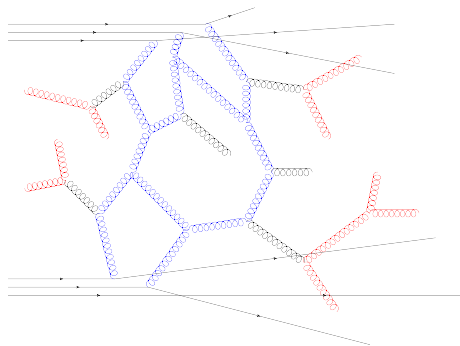
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Modifications

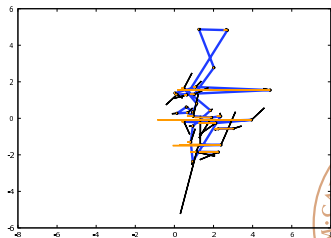
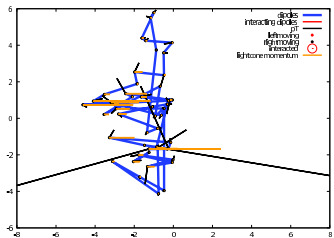
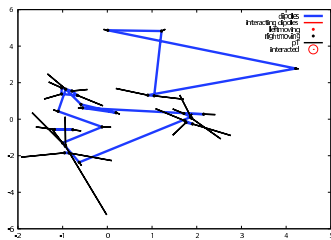
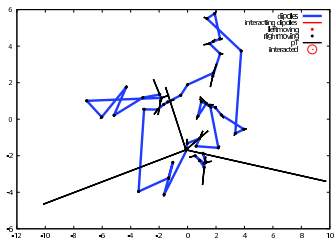
Interaction Probability and p_T

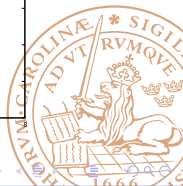
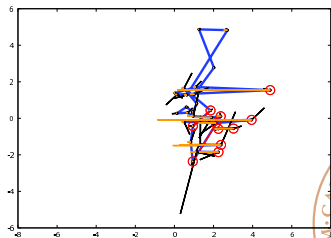
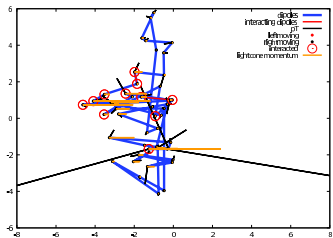
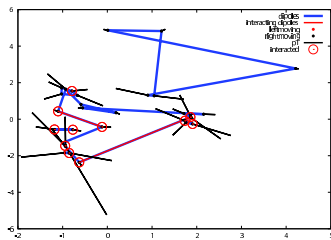
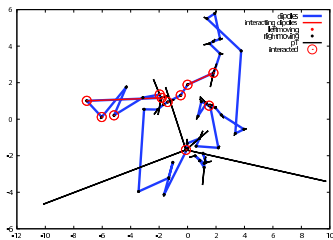
- ▶ Interaction distance $r \Leftrightarrow$ momentum $p_T = 1/r$.
- ▶ Interaction amplitude $f_{ij} = \frac{\alpha_s^2}{2} \ln^2 \left(\frac{r_{13}r_{24}}{r_{14}r_{23}} \right)$ gives exact r distribution.
- ▶ Interaction amplitude $f_{ij} = 8\alpha_s^2 \sin^2 \left(\frac{r \cdot r_{12}}{r^2} \right) \sin^2 \left(\frac{r \cdot r_{34}}{r^2} \right)$ gives exact p_T amplitude. Better.

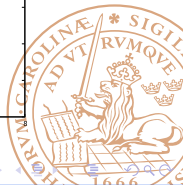
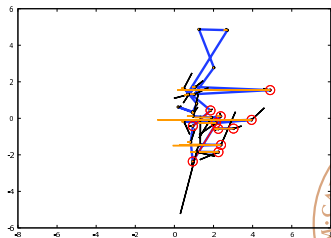
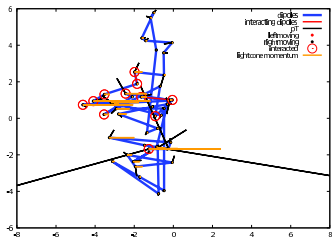
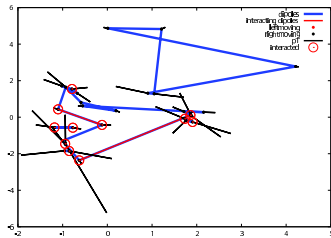
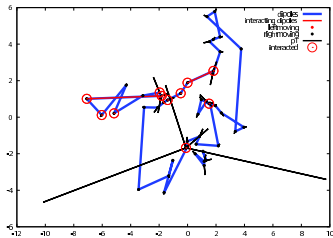
Require that colour connected partons should be p_+ and p_- ordered.

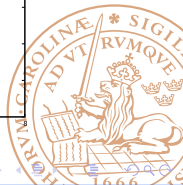
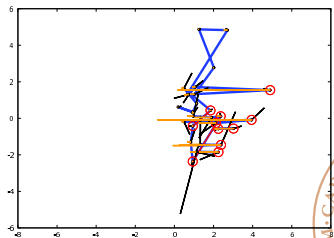
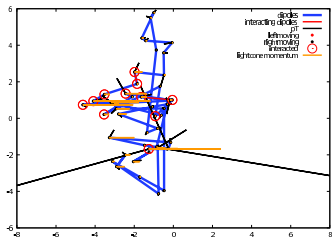
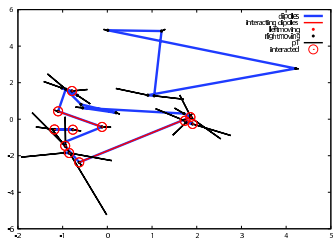
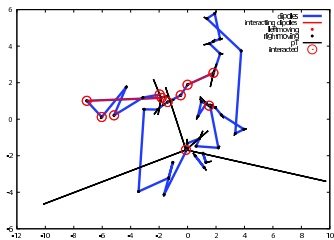
- ▶ Prevents double counting with final state radiation.
- ▶ Does not contribute much to total cross sections.

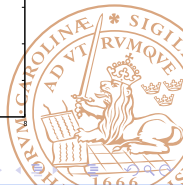
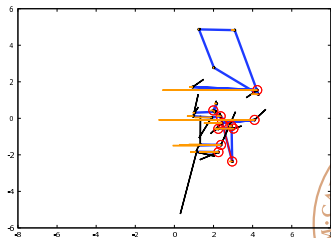
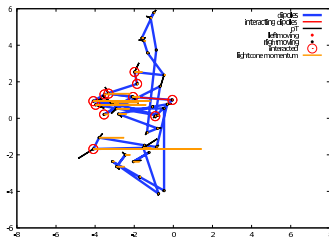
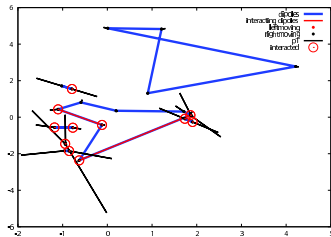
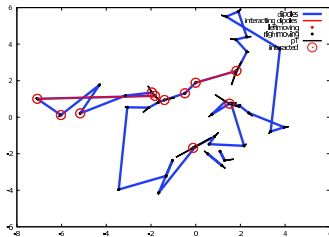


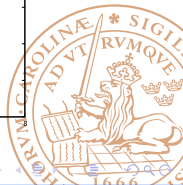
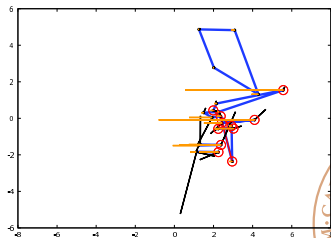
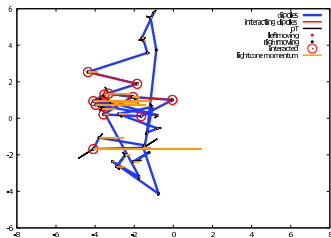
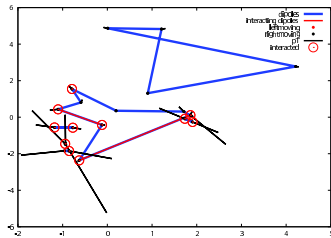
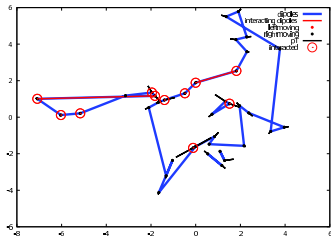


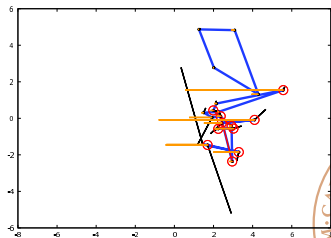
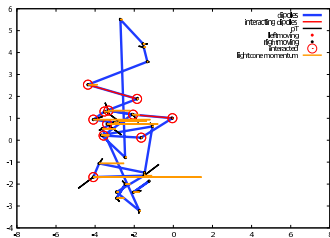
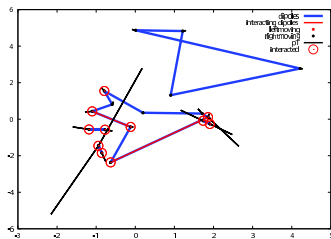
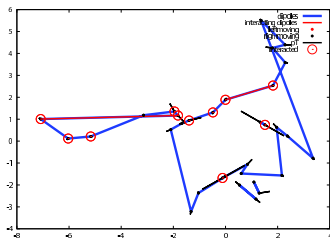


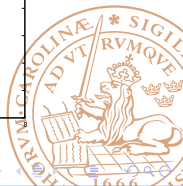
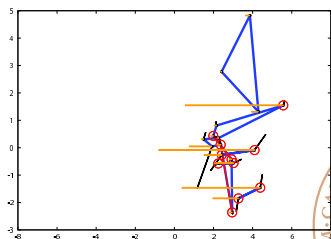
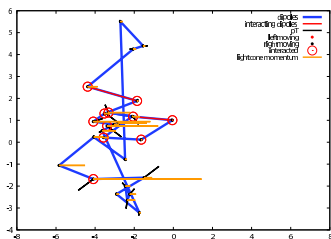
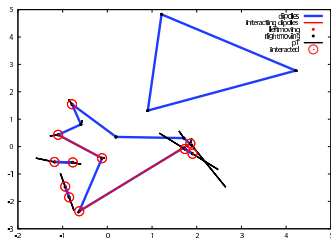
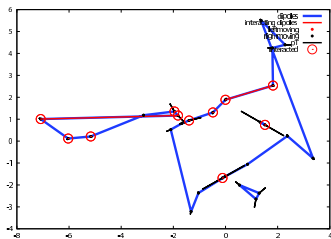


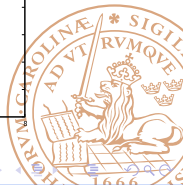
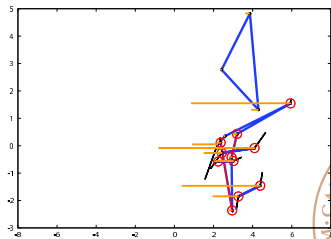
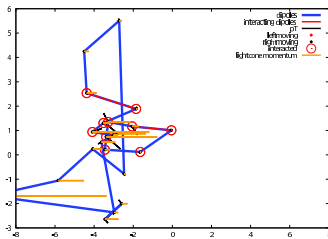
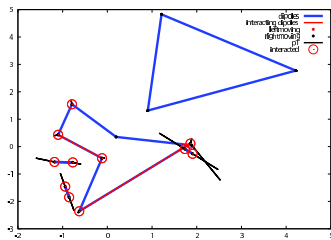
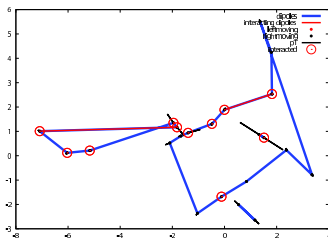


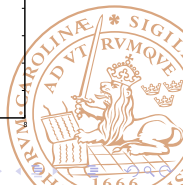
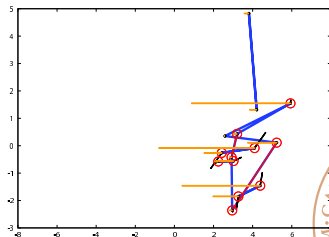
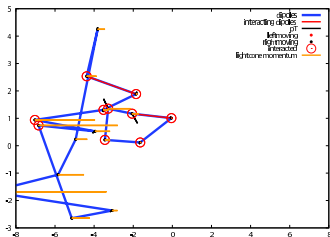
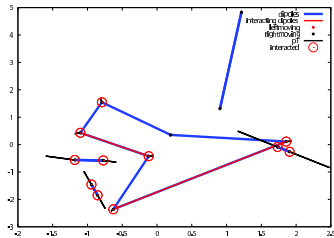
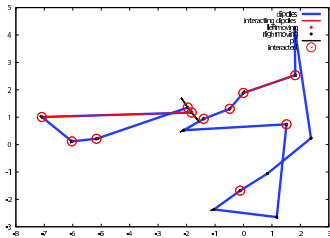


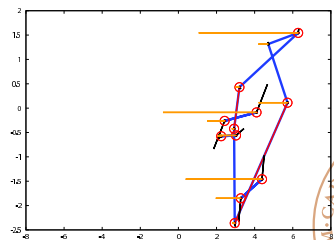
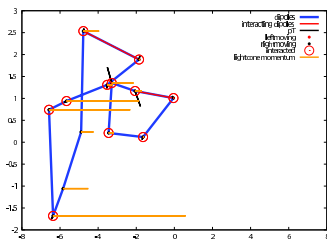
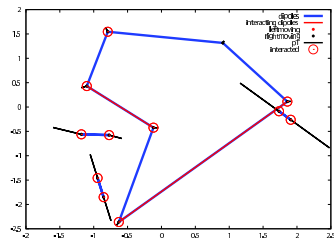
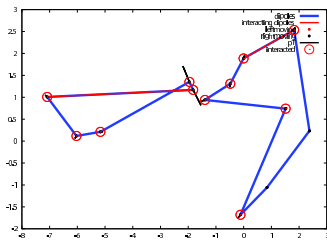


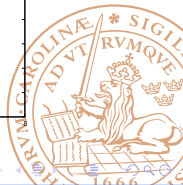
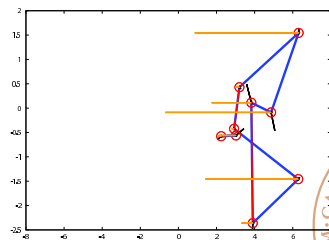
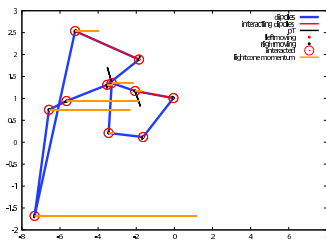
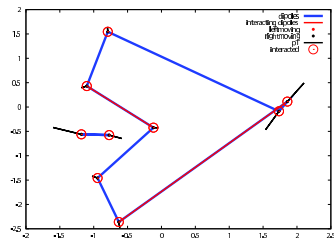
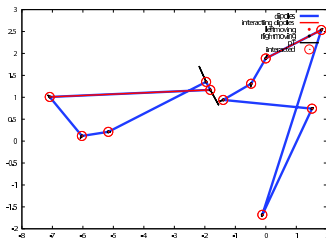


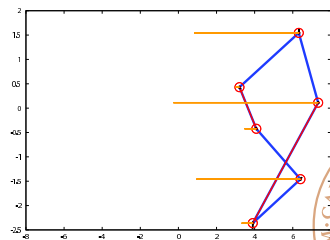
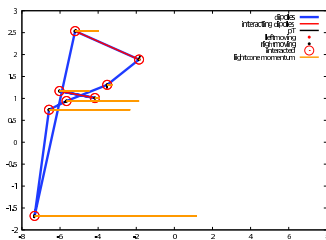
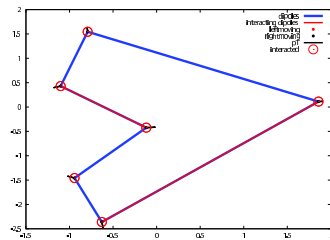
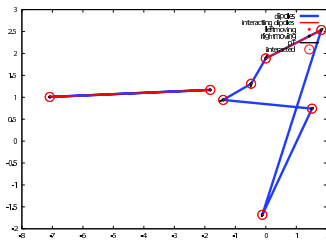


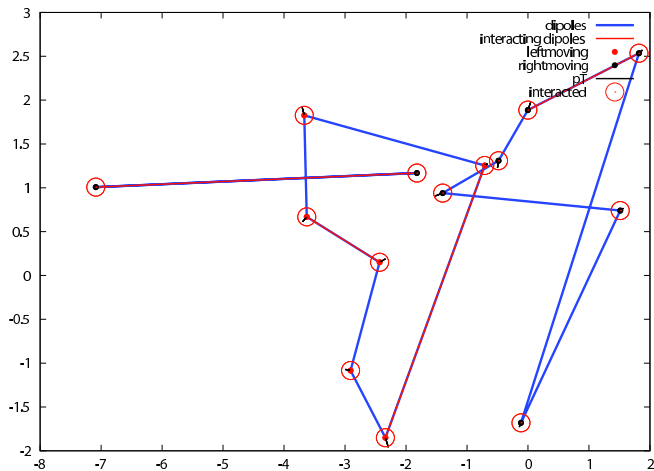


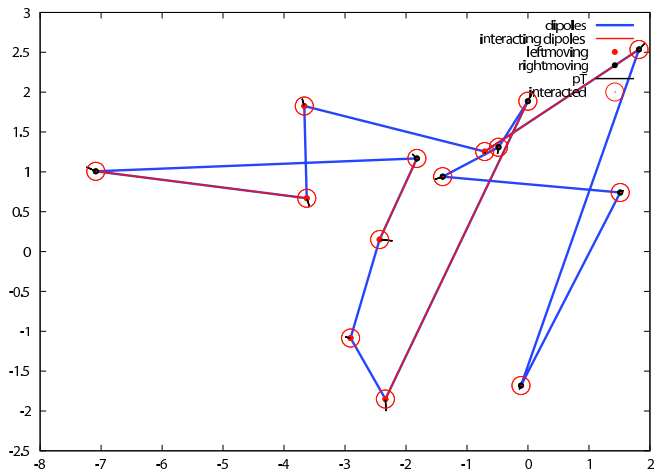




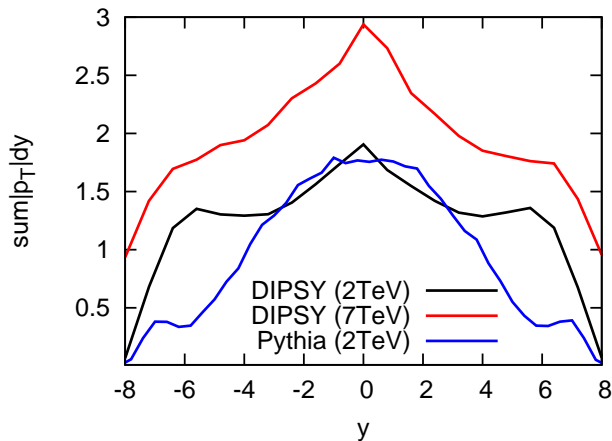








Preliminary results



Heavy Ions: A new field

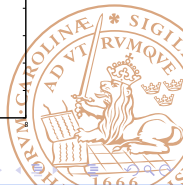
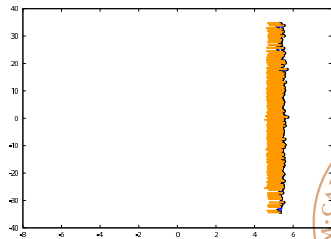
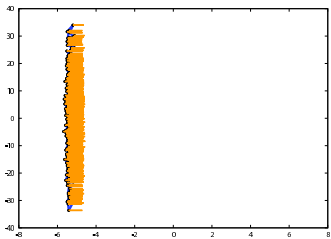
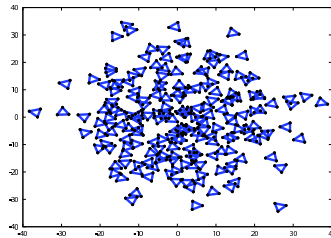
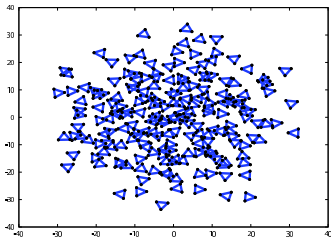
Distribution of nucleons from collaborators András Ster and Tamás Csörgő.

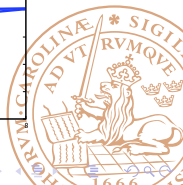
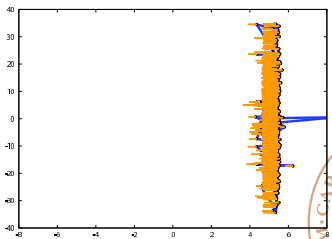
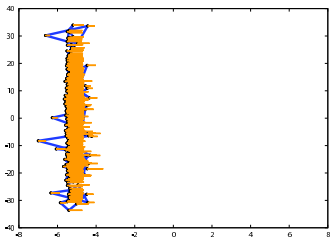
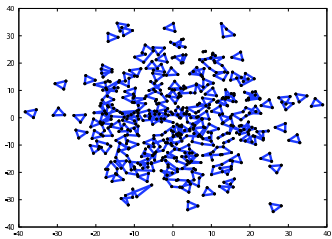
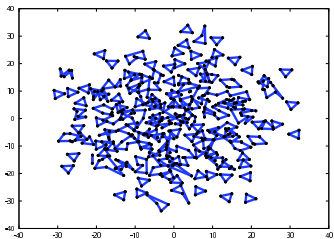
Then evolve, collide and absorb as for pp .

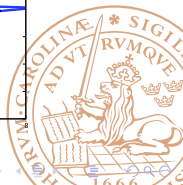
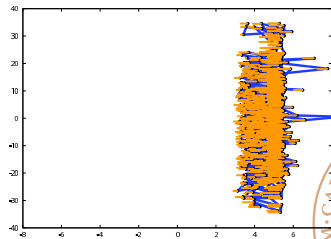
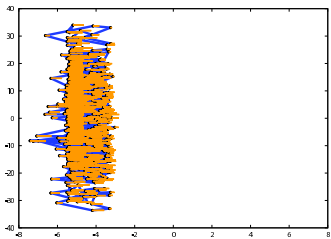
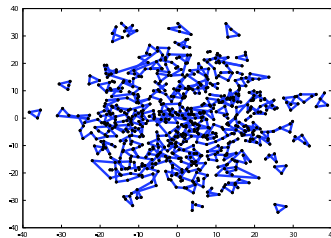
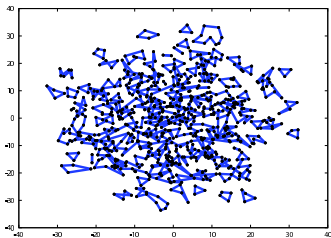
In principle same dynamics as Colour Glass Condensate.

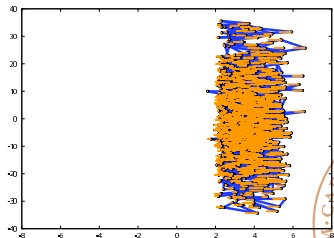
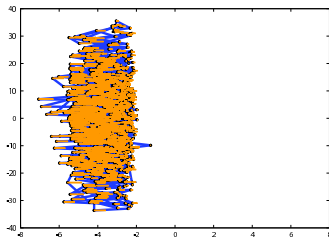
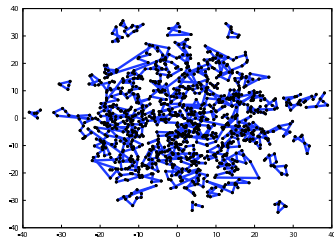
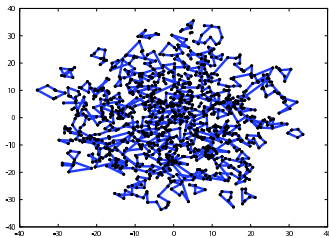
- ▶ DIPSY uses finite size nucleus.
- ▶ DIPSY works at limited energies, for example at RHIC and LHC.

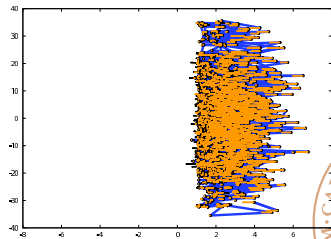
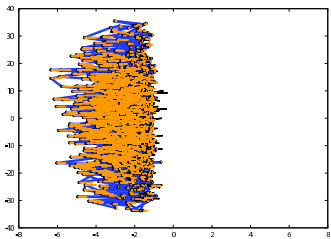
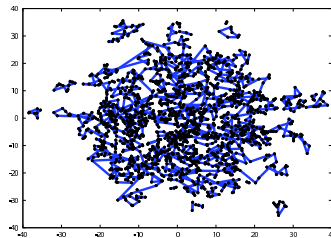
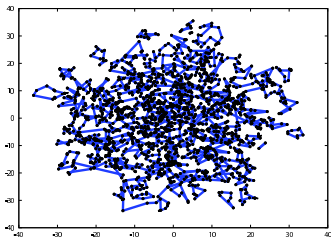


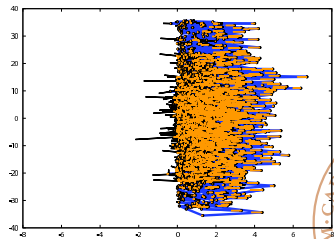
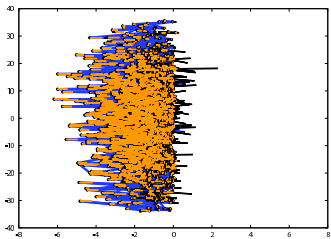
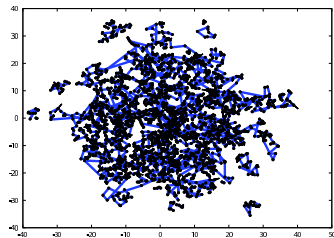
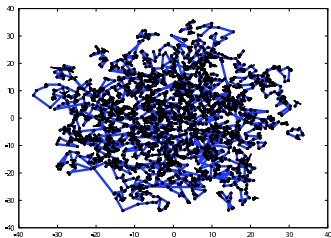


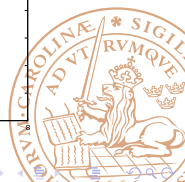
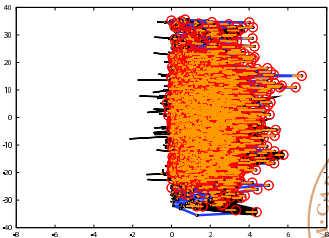
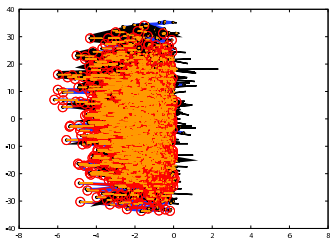
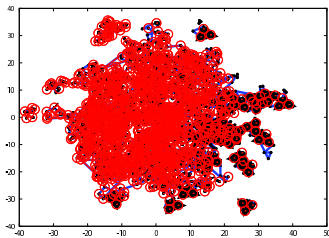
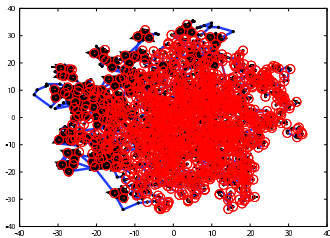


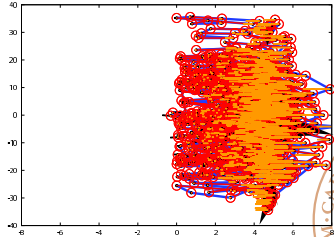
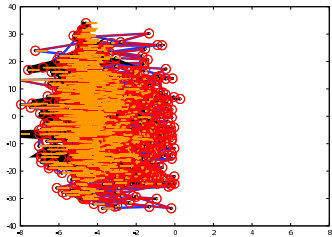
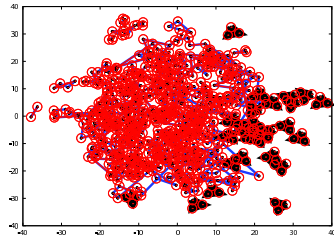
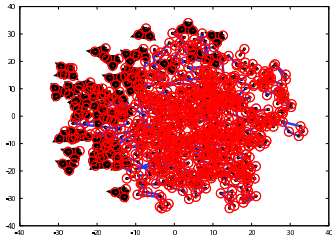


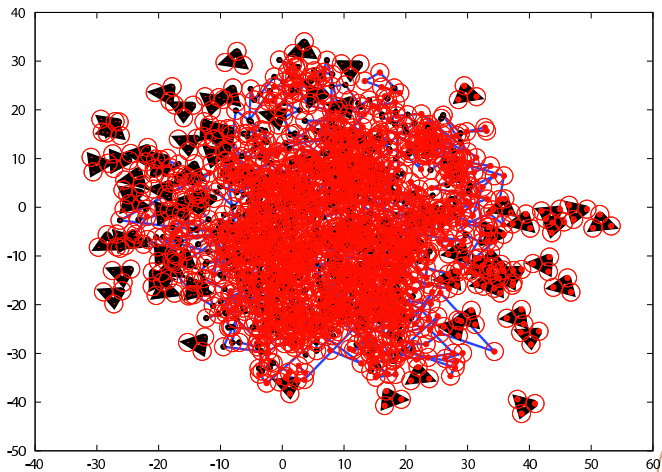


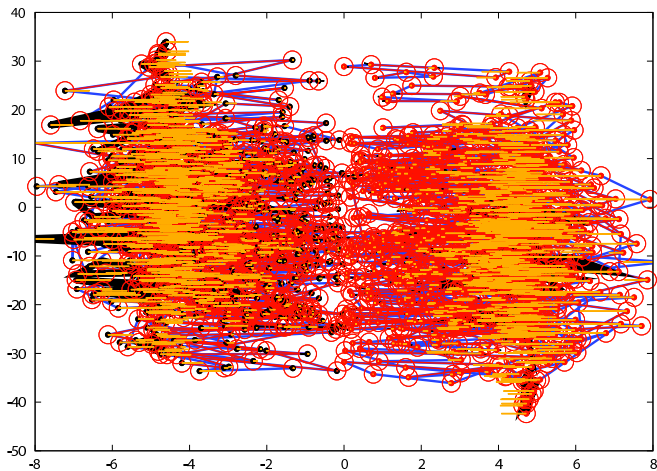


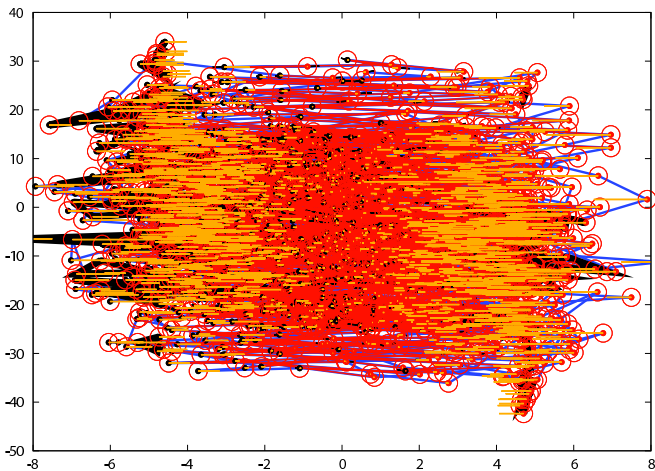




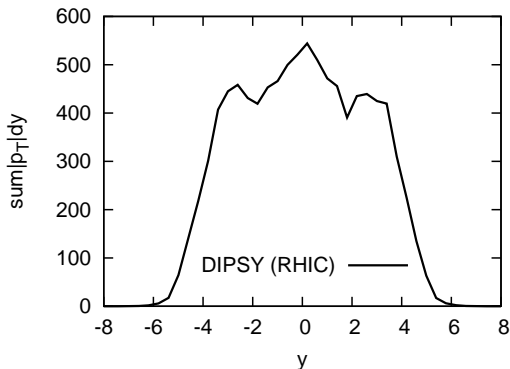








VERY preliminary results



Have p_{μ} , x_T and colour flow for every parton in the nucleus, just after the collision.

Can then be plugged into final state models, as for example hydrodynamics.



Conclusions

- ▶ Evolution of dipoles in space and rapidity.
- ▶ Inclusive cross sections match wide set of data very well with few parameters.
- ▶ Exclusive final states complicated, but almost sorted out now!
- ▶ Applications in Heavy Ions.



small dipole absorb

Dipoles come with relative weight of $1/r^2$ in evolution as seen from emission amplitude.

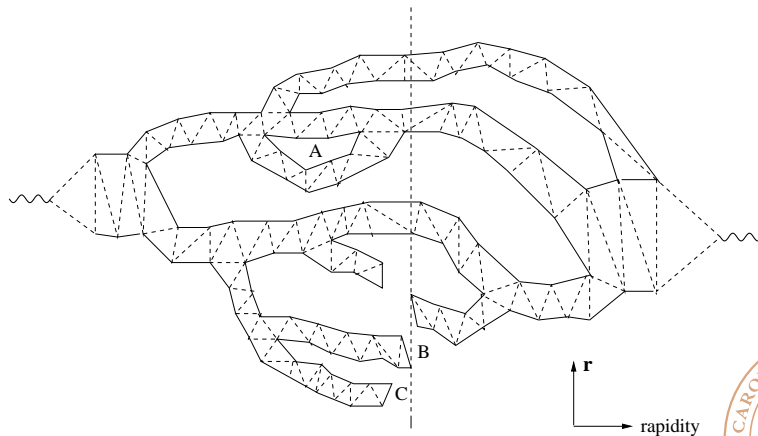
high p_T events should come with weight of $d^2 p_T / p_T^4 = d^2 r$.

So small dipoles in evolution (giving large p_T) are too frequent.

Solution: Absorb small dipoles. Keep with a probability $p \propto r_{small}^2$. Then final weight for small dipoles will be $d^2 r$ as we want.



Virtual Partons



Divergent mueller evolution

No problem since small dipoles are unlikely to interact.

Infinitely many small dipoles, but finite total interaction probability.

Inconvenient for monte carlos though.

