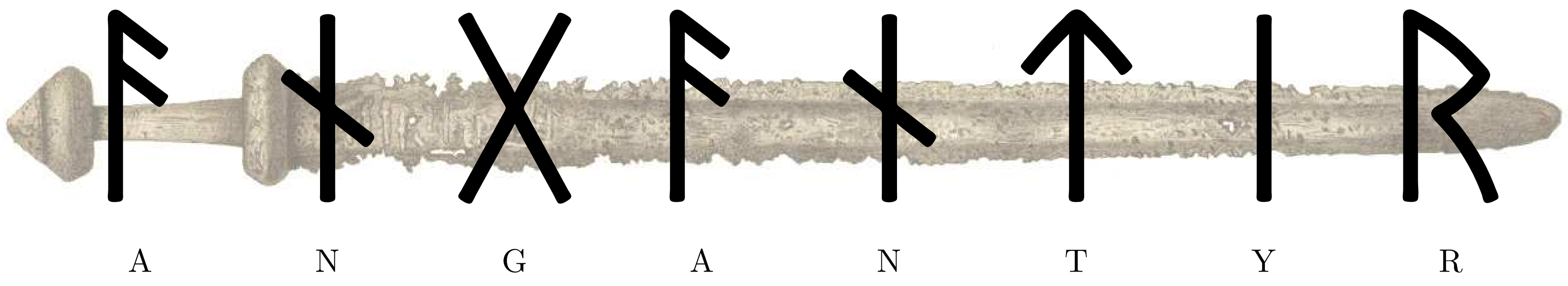
What, Where and When is *the Medium*

Leif Lönnblad
leif.lonnblad@thep.lu.se
In coll. with C. Bierlich, S. Chakraborty, G. Gustafson and H. Shah

The Medium

When discussing jet quenching we often talk in terms of a ***jet*** being modified by ***the medium***. This medium is, of course, made out of quarks and gluons. It may or may not be a Quark-Gluon Plasma in thermal equilibrium. Most likely it will not be in thermal equilibrium at the actual moment of collision. Also the jet is made up of quarks and gluons, so it makes sense to describe the jet and the medium inside the same framework. At least in the beginning. This is what we try to do in

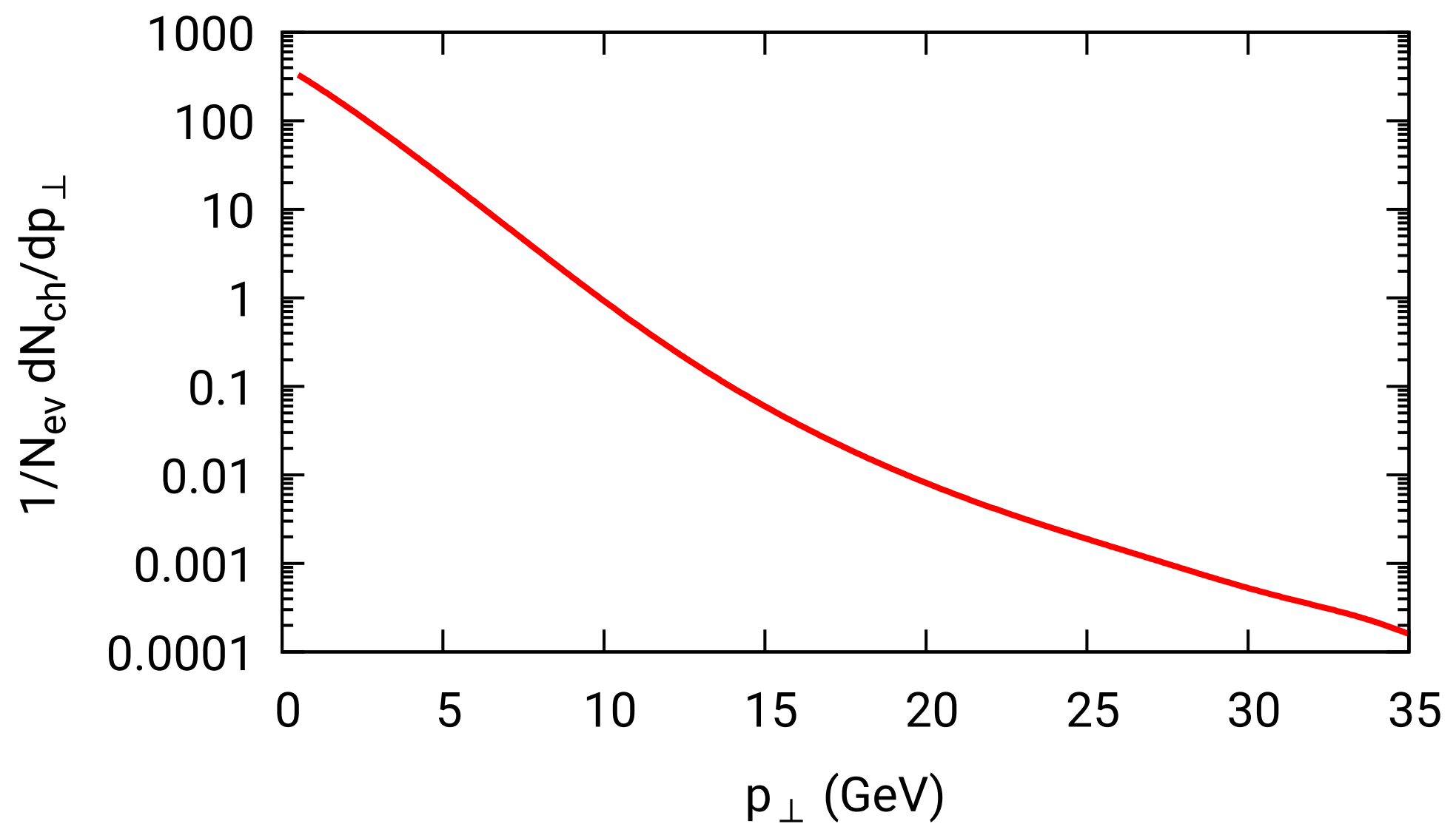


Angantyr

AGANTYR [1] employs the full power of **PYTHIA8** [2] to build up the initial state of a collision between heavy ions. Each nucleon–nucleon collision is simulated with the PYTHIA8 multi-parton interaction machinery, taking into account that a nucleon in one nucleus may interact with several nucleons in the other.

Currently each of these sub-events are generated and hadronised independently, so no collective effects are included. Nevertheless it gives a surprisingly accurate description of experimental data on multiplicity distributions and single particle spectra.

This gives us some confidence that we have a reasonably good description, at least of the initial partonic stages of heavy ion collisions.



Dipoles and Strings

In the development of parton showers and hadronisation models in event generators we have learned that the important degrees of freedom in a partonic system is ***dipoles*** and ***strings***:

- On the perturbative level parton evolution is described as radiation from *dipoles* between colour-connected partons.
- The non-perturbative hadronisation process is best described in terms of fragmentation of *string* spanning colour-connected partons.

The radiation from and hadronisation of a hard parton in a jet must depend on the way it is connected with other (softer) partons (in *the medium*). We want to treat the jets and the medium inside the same framework.

In heavy-ion collisions and in high multiplicity pp collisions there are very many coloured partons and they can be close together both in position and momentum space. We need to understand what this implies for the evolution and hadronisation.

String interactions

In a series of papers [3-5] we have investigated possible changes to the dipole/string picture in dense environments, and have come up with three models that are able to reproduce many experimental observations of collectivity in high multiplicity pp event.

- **Swing** (or *colour reconnection*): There are only three colours, so it is not obvious to which anti-coloured parton a given coloured parton should be connected. In the Swing model two identically coloured dipoles are allowed to reconnect in a way that minimises the *string length*.
- **Ropes**: Strings have a finite thickness ($\sim$ 1 fm) when they break. If strings overlap it will result in an increased string tension, which affects the probability to produce eg. strange quarks when they break.
- **Shoving**: The increased string tension means that before overlapping strings break ($\tau \approx 2$ fm/c) they will repel each other, giving flow effects. Long parallel string will give a ridge. (see also poster by S. Charkraborty).

For all these models it is important to have a detailed picture of **where** and **when** the strings/dipoles overlap, as well as the momenta of the connected partons. This is provided by PYTHIA8/AGANTYR.

Questions

- Where and when does a jet evolve and hadronise?
- How is it colour-connected to the *medium*?
- How is the hadronisation affected by other strings in the event?
- Can the jet be *shoved* by the *medium*?
- Is the *medium shoved* by the jet?
- What are the implications for jet subtraction?

References
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2. T. Sjöstrand et al., Comput. Phys.Commun. 191 (2015) 159.
3. A. Avsar et al., J. High Energy Phys. 01 (2007) 012.
4. C. Bierlich et al., J. High Energy Phys. 1503 (2015) 148.
5. C. Bierlich et al., Phys. Lett. B779 (2018) 58.