Holmganga - Summary of CGC vs. Lund strings

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CGC/Glasma vs. Strings

CGC/Glasma	Strings
$\varepsilon \sim$ 500 GeV/fm^3 ($\tau_0 = 0.1$ fm/c) $\propto 1/\tau$	$\varepsilon \sim$ 5 GeV/fm^3 constant
Energy of the field (virtual gluons) must be present in thecentral rapidity from the beginning	Energy in the string is gradually built up, taken from the string ends – partons that have come on-shell by MPI.
"Glasma tubes" breaks down to QGP after $\sim$ 0.5 fm/c	Transverse colour-magnetic currents build up to confine colour-electric fields in strings (ropes) after $\sim$ 0.5 fm/c

Summary on session 2

- Difference in energy scales explained as $\epsilon \sim p^4$. The scale for Pythia Λ_{QCD}, for CGC Q_s.
- In Angantyr picture strings grow in time. In the CGC picture the correlations are there already at the IC.
- In CGC initially negative longitudinal pressure. Realized later: In Angantyr picture this is (probably) not the case due to helical (transverse) magnetic field.
- Open question: instabilities in the Angantyr picture (Weibel).

Energy density @ $\tau = 0.1$ fm   lesson learned @ Holmganga, T. Lappi

Striking difference : Angantyr : 5 GeV/fm^3 IPglasma : 500 GeV/fm^3 (Central Pb-Pb)

But: this only includes strings, not gluons @ $\tau \simeq 0$

How do these nevertheless agree with same exp't'l data ?

- PYTHIA : beams are pulling ends of strings => transfer more energy to midrapidity for long time: $\varepsilon\tau = \frac{dE}{d\eta}$ increases with τ
- Hydro : $p\,dV$ work pushes energy away from $\eta = 0$:
  $dE/d\eta|_{\tau=0.1} \approx 50$ GeV/fm^2 $\xrightarrow{p\,dV}$ 15 GeV/fm^2 → 1500 GeV for $\pi R_A^2 \simeq 100$ fm^2
  $\Rightarrow \frac{dN}{d\eta} \gtrsim 2000$ with $\langle p_\perp \rangle \gtrsim 0.5$ GeV measured ~> natural!

How to measure $\varepsilon(\tau = 0.1$ fm ... 1 fm$)$? Jet que. ? Thermal photons ?

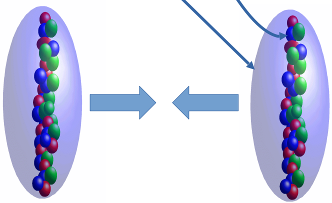
- kt-factorization formula (DHJ, KLN, rcBK evolution) + Lund string fragmentation

hard | semi-hard | soft

pQCD 2 -> 2 Q_s CGC 2 -> 1 Λ_{QCD} String excitation

- Particle + classical YM simulation based on Vlasov-Boltzmann:

$$D_\mu F^{\mu\nu} = J^\nu \qquad p^\mu\left(\frac{\partial}{\partial x^\nu} - g f^{abc} A^b_\nu Q^c \frac{\partial}{\partial Q^a} - g Q_a F^a_{\mu\nu} \frac{\partial}{\partial p_\nu}\right) f(x,p,Q) = I_{\rm coll}$$



hard source J: large x parton: Wong's equaton

YM classical field F: small x gluon: YM equaion

I_{coll}: use Pythia for the scattering between large x partons

Contributed summaries, session 5

- There is really no problem with the large difference in the energy density difference between the Lund String picture and the CGC. The main difference being that the energy densities are in the LS case not including emissions, since they are not in the field, but the CGC treatment is all inclusive.
- There seems to be a main conceptual difference between Lund string interaction treatments and hydrodynamic treatments of final state interactions, in that hydro would start with a lot of energy in the mid-rapidity bin which then flows out in the longitudinal direction, whereas in Lund strings the energy is in the end-points/remnants in the beginning, and transported in to the central region as time goes on.
- There is a general problem in the way hadronic cascades are applied more or less blindly after freezeout. No matter the model in question, hadrons will be produced occupying the same space-time volume, and it is unclear if hadronic cross sections can then be applied. The problem is larger for Pythia, due to early fragmentation.

Contributed summaries, session 6

- How to extract η from Angantyr events, or $T^{\mu\nu}$? At early times seems like ill defined problem.
- Different signatures between helical vs. longitudinal chromomagnetic fields?
- Is there a heavy quark observable that is sensitive to the differences between the Angantyr picture and CGC picture?
- Using Pythia as an initial condition for the CGC. The idea is to take the position and momenta of gluon from the MPI of pythia, and use it to set the CGC sheets
- Other idea is to collide two DIPSY sheets and see whether we get the results similar to IP glasma
- We need to have results from the PYTHIA and EPOS side to further understand the nuclear deformation parameter

Contributed summaries, session 7

- CGC correspond to all the gluons after all initial emissions/radiations
- strings in PYTHIA are real QCD objects and not just an hadronization tool.
- PYTHIA/Angantyr push the concept of having only string to extreme energy densities to see what can come out but probably not the more realistic approach.

Energy density issue

- Problem: Energy density in Angantyr 100x smaller than in CGC.
- Solution: different time-evolution:
  - CGC: all energy deposited at mid rapidity at $\tau = 0$.
  - Angantyr: Energy is gradually transported from beam remnants to midrapidity. Thus initial system is much more dilute.
- Ideas for future/discussion/takeaway:
  - Impact of large/small energy densities on jets/jet quenching $\hat{q}$?
  - Thermal photons (a longstanding problem) $T \sim \sqrt[4]{\epsilon}$.