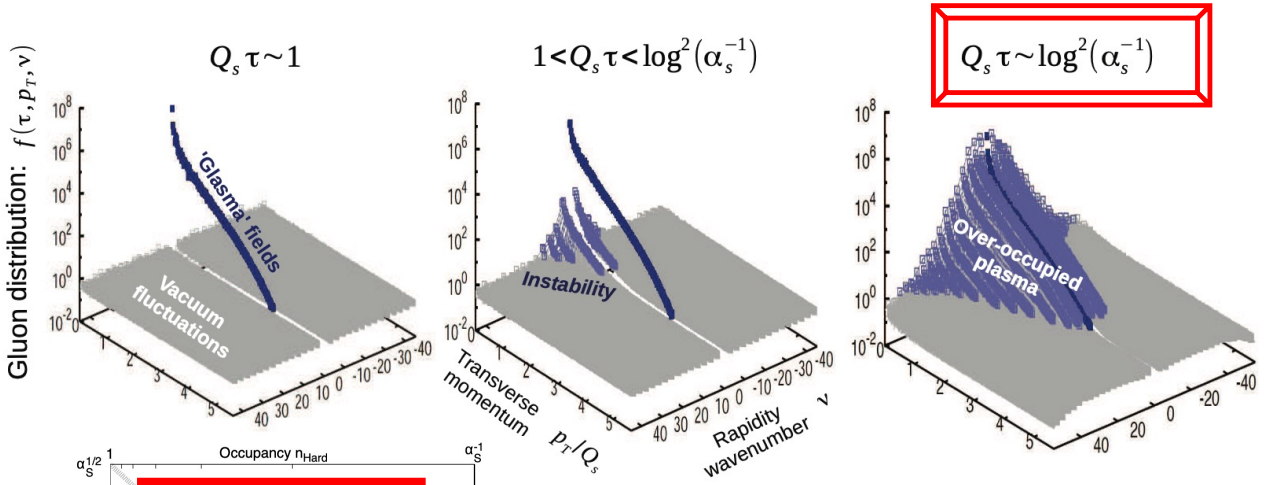
Collectivity from QCD

CGC/Glasma EFT has a rigorous connection to underlying theory when $Q_S >> \Lambda_{QCD}$, with $\alpha_S(Q_S) << 1$

α_S f ~ 1 is the parameter that generates strong correlations; matches to pQCD systematically when α_S f << 1

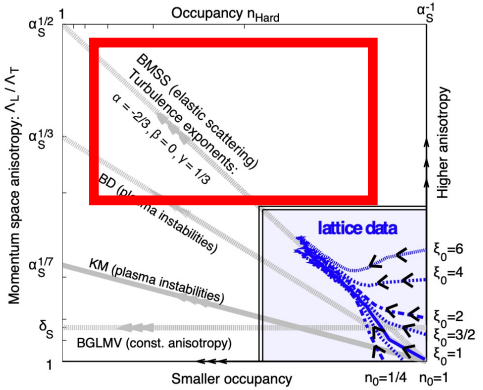
Full 3+1-D
CGC / Glasma
classical-statistical
simulation

Berges,Schenke,Schlichting,RV
arXiv: 1408.1638



This system evolves to a
turbulent attractor -
the "bottom-up" (BMSS)
effective kinetic theory

Baier,Mueller,Schiff,Son,
hep-ph/0009237



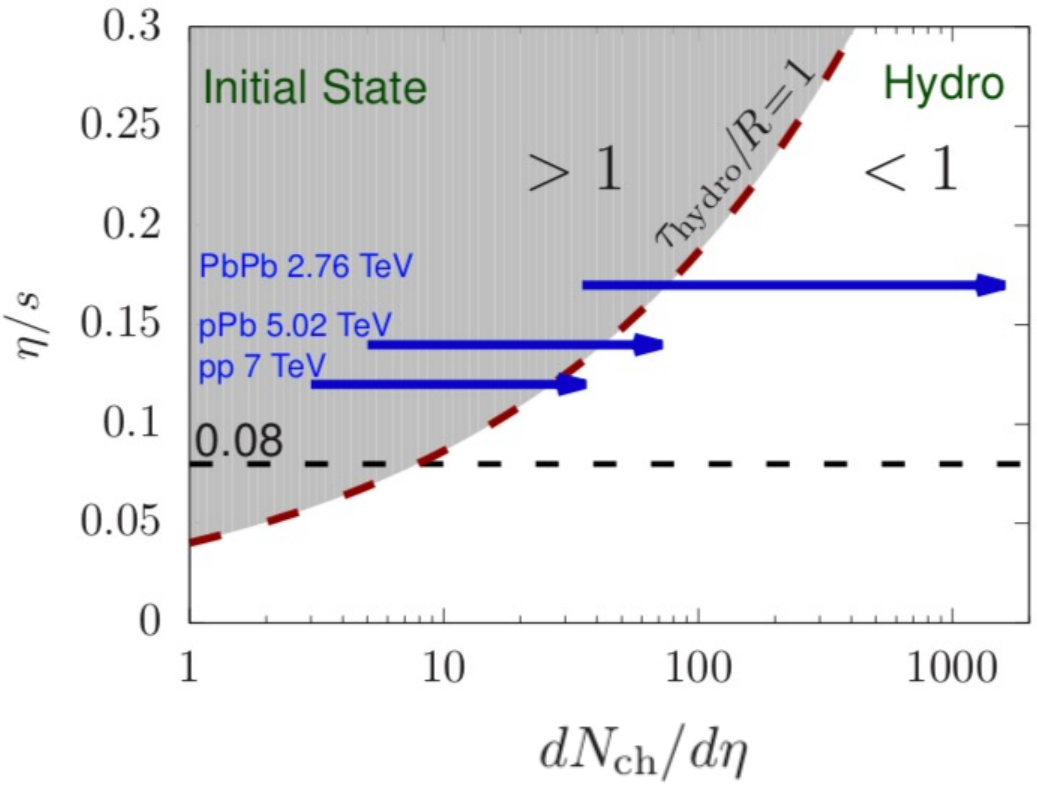
CGC/Glasma leads to bottom-up thermalization…

$$\tau_{therm} = \frac{1}{{\alpha_s}^{13/5}} \frac{1}{Q_S} \rightarrow \frac{(Ln\,(Q_S/\Lambda_{QCD})^{13/5}}{Q_S}$$

$\rightarrow 0$ *when* $Q_S \rightarrow \infty$

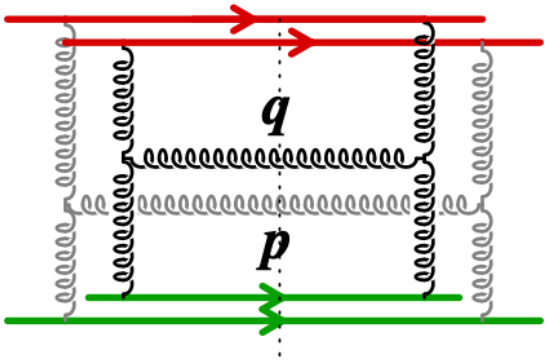
very rapid thermalization for increasing Q_S

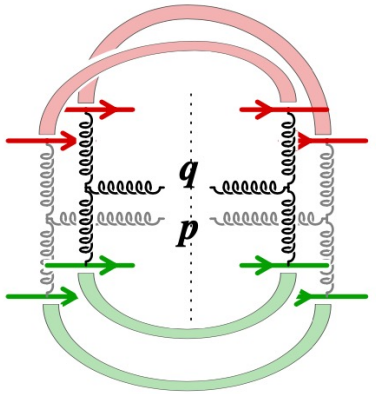
Collectivity from QCD



Mazeliauskas, arXiv:1807.05586
Kurkela,Wiedemann,Wu, arXiv:1905.05139

What about initial state momentum anisotropy?





Original motivation:
This "MPI" quantum interference diagram in QCD
is also enhanced at high multiplicities…
and can lead to a large azimuthal anisotropy

Dumitru,Gelis,McLerran,RV, arXiv:0804.3858
Dumitru et al., arXiv1009.5295

However this effect is large for q~p~Q_S and is strongly diluted for smaller Q_S
- In particular, from the multi-particle interactions (very strong for $p < Q_S$, see previous slide)
going on within the same framework…

It would be very interesting and fundamental (having to do with quantum entanglement ideas) to be able to uncover such correlations but this looks to be challenging because of the difficulty of separating initial from final correlations

Other ideas for entanglement (hyperon "spin" correlations) may be more interesting for long-range "Bell-type" quantum effects