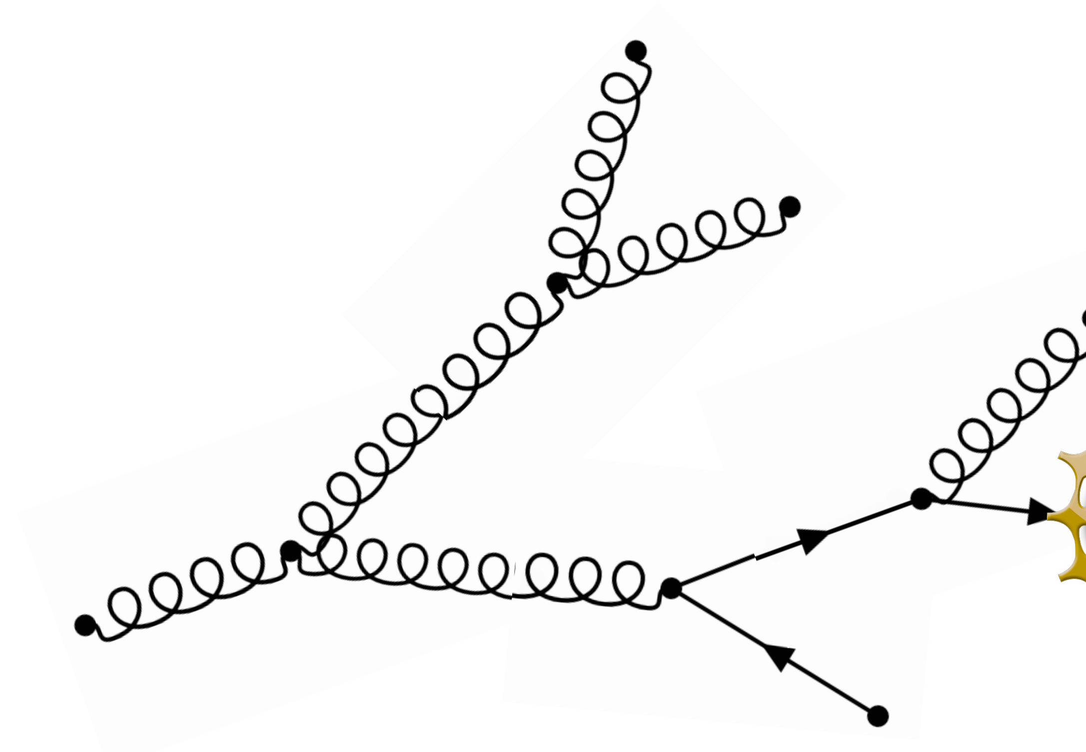
Energy loss and thermalization of highly energetic partons/jets in QCD kinetic theory

Based on
Y. Mehtar-Tani, S. Schlichting
I. Soudi, in preparation



also see earlier work
Y. Mehtar-Tani, S. Schlichting JHEP 09 (2018) 144
S. Schlichting, I. Soudi JHEP 07 (2021) 077

WAYNE STATE UNIVERSITY

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Strong-interaction matter under extreme conditions

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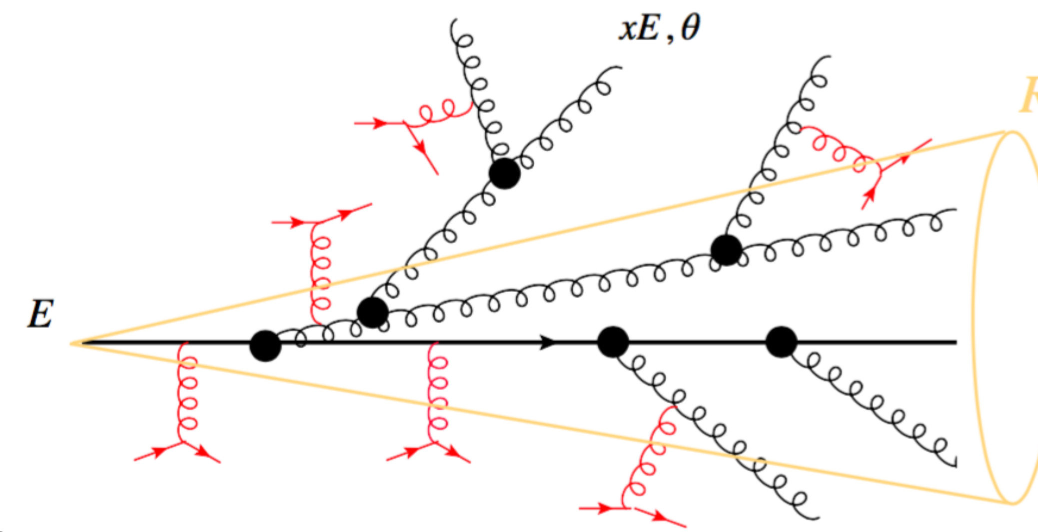
Scope/Motivation/Methodology

Jet quenching phenomena in HIC probe variety of different aspects of QCD

initial production, vacuum shower, energy loss, medium response, hadronization



Develop clear understanding of mechanism for degradation of energy, out-of-cone energy loss, medium response and thermalization of hard partons/jets

Describe in-medium evolution in QCD kinetic theory (HTL screened 2<->2, eff. 1<->2 processes) with Jet as linearized perturbation on top of equilibrium background

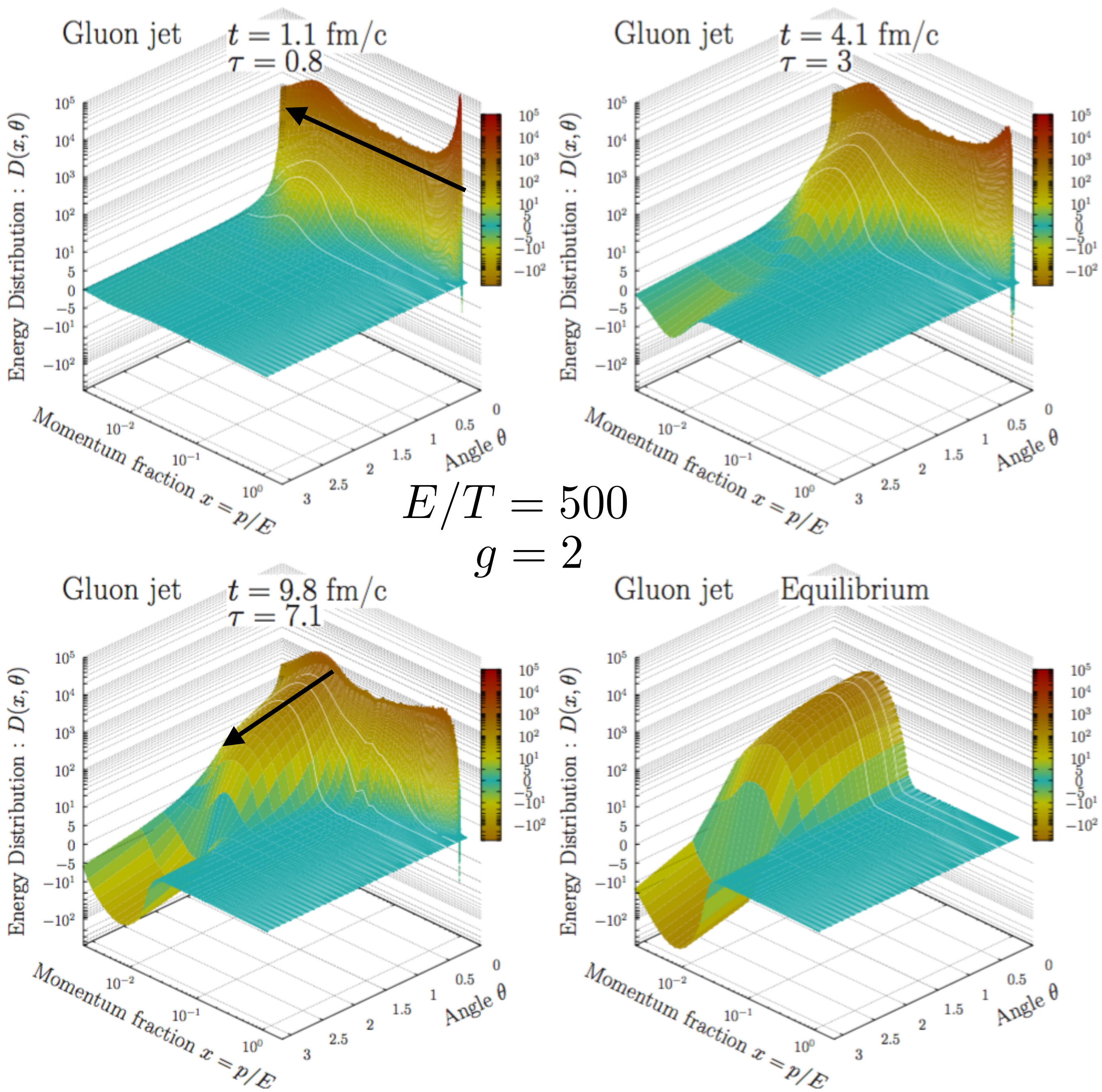
$$\left(\partial_t + \frac{\boldsymbol{p}}{|\boldsymbol{p}|}\nabla\right) f_a(\boldsymbol{p},\mathbf{x},t) = -C_a^{2\leftrightarrow 2}[\{f_i\}] - C_a^{1\leftrightarrow 2}[\{f_i\}]$$

same setup as in studies of thermalization of QGP at early times

Out-of-cone energy loss & Jet thermalization

Characterize evolution in terms of energy distribution $D(t,x,\theta) = x\dfrac{dN}{dx\,d\cos(\theta)}$

starting from initial state of single primary quark/gluon (Green's function)



Out-of-cone energy loss:

1) Energy deposition into soft sector via nearly collinear cascade of radiative break-up confined to narrow cone θ<0.3

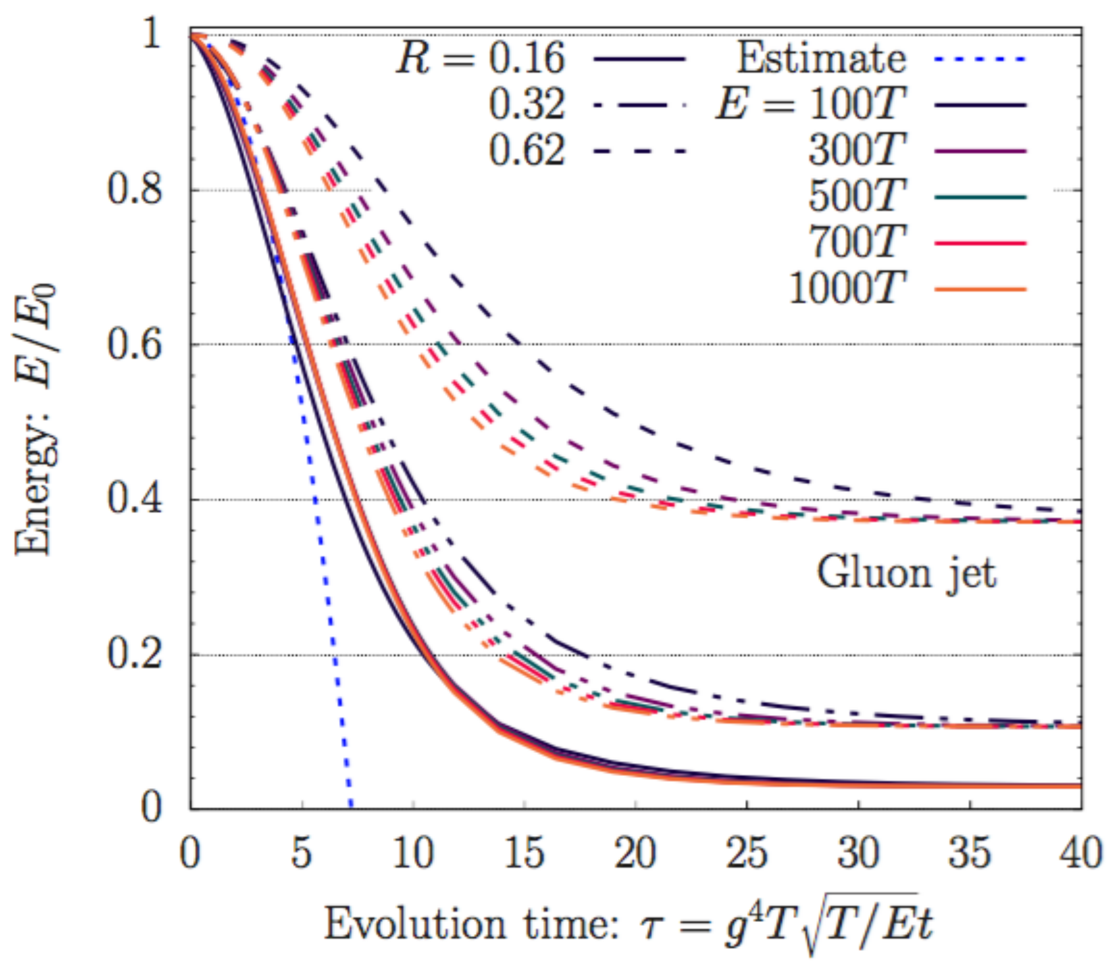
2) Soft fragments (x~T/E) spread out to large angles (θ~1) via elastic interactions

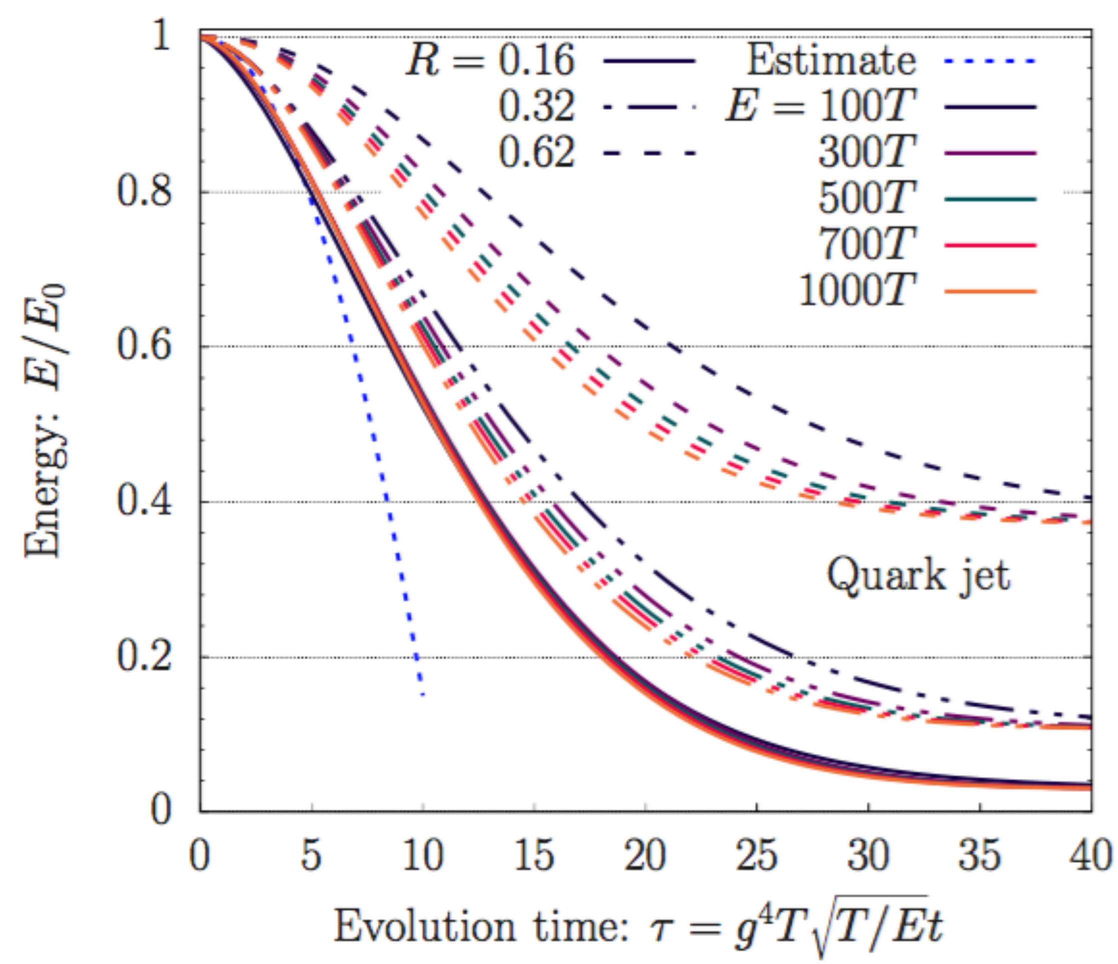
Eventually jet thermalizes, when all hard parsons have decayed

Out-of-cone energy loss & Jet thermalization

Out-of-cone energy loss for narrow cones (R~0.3) governed by radiative break-up of hard fragments + rapid broadening of soft fragments

Energy (E/T) dependence governed by radiative rates



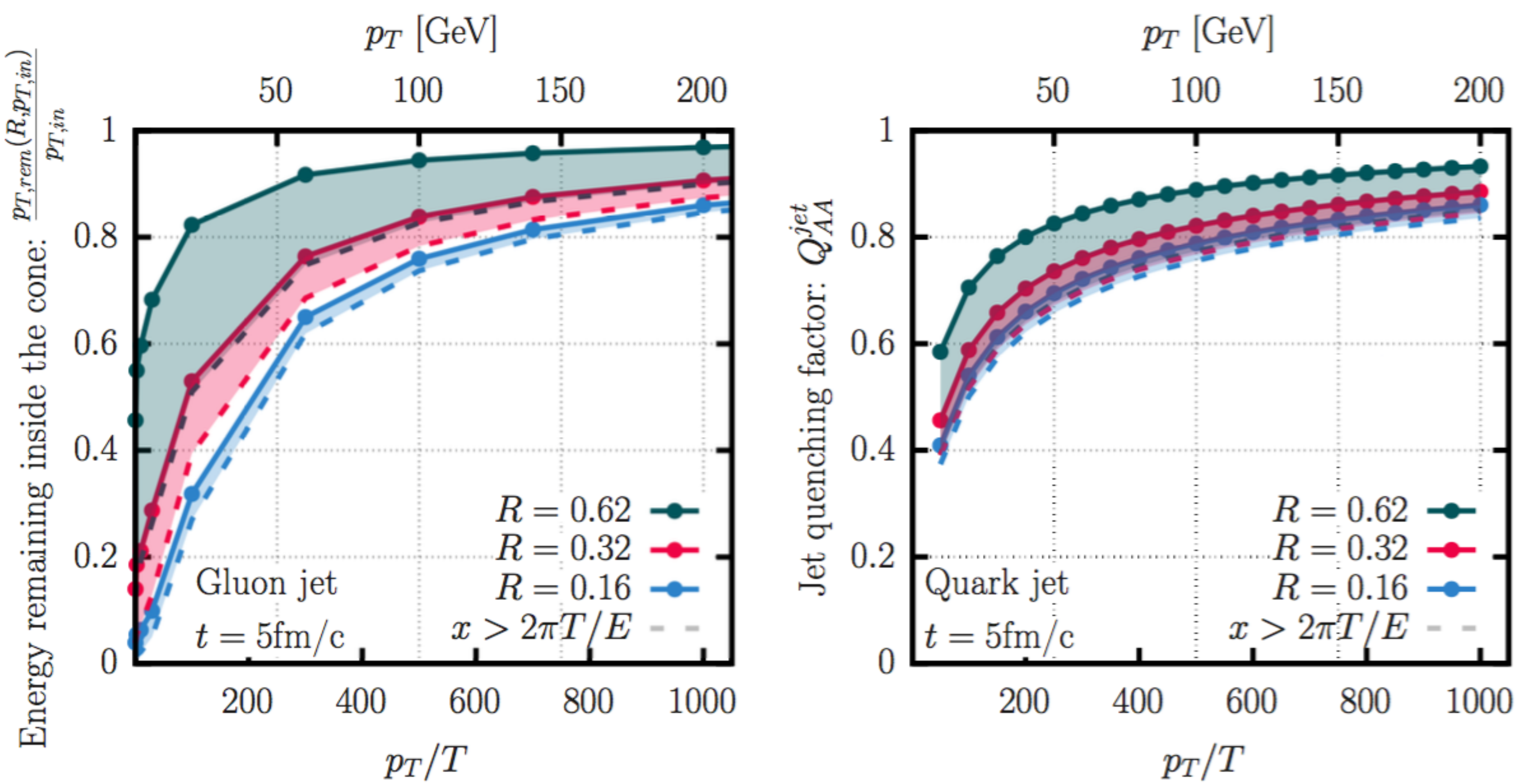


Significant recovery of energy of soft thermal fragments beyond R~0.3

Jet Quenching

Stochastic emission with BDMPS rate dΓ/dω sub-sequently use QCD Kinetic theory to calculate energy remaining inside jet cone

$$Q(p_T) = \exp\left[\int_0^L \mathrm{d}t \int \mathrm{d}\omega \frac{\mathrm{d}\Gamma}{\mathrm{d}\omega}\left(1 - \mathrm{e}^{-n\frac{\omega}{p_T}\left[]1-E\left(\omega,R,\tau=\frac{L-t}{t_{\mathrm{th}}}\right)\right]}\right)\right]$$

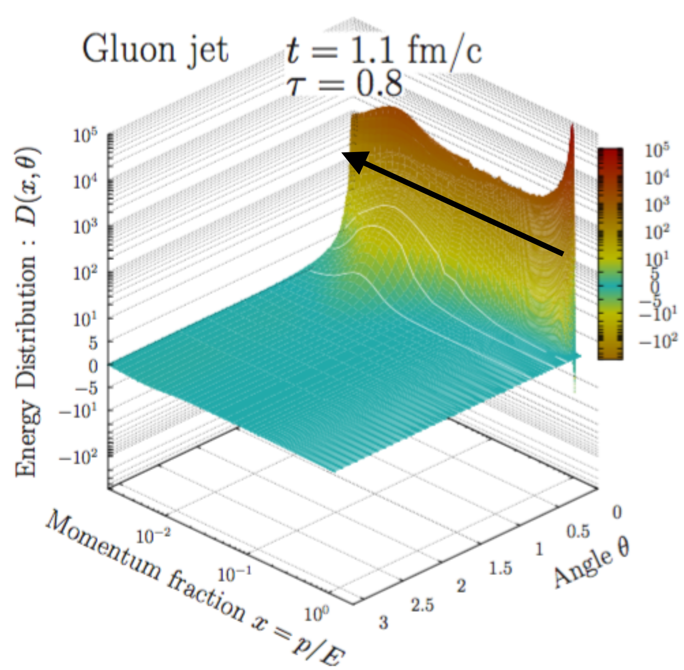


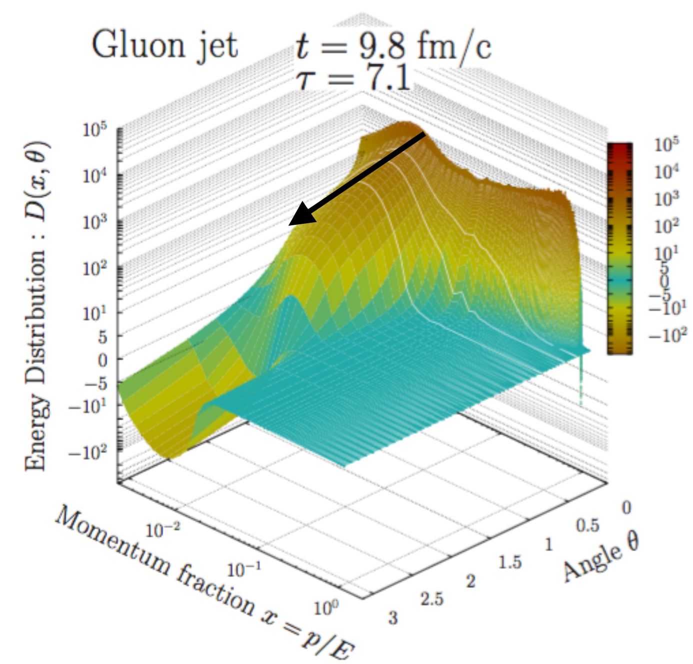
Sensitivity to soft sector for R>0.3; this is where to search for medium response

Conclusions & Outlook

Out-of-cone energy loss and thermalization of highly energetic partons/jets governed by nearly collinear cascade + broadening of soft fragments

Dynamics accessible via variations of cone-size R and energy range pT_{min}; also interesting consequences for jet chemistry





Green's functions for energy loss of soft fragments can be used in semi-analytic calculations of jet quenching observables

First step towards development of MC Generator for unified description of jet quenching & medium response within QCD Kinetic Theory