JET Collaboration Meeting

UC Davis, June 17-18, 2014

Status and progress

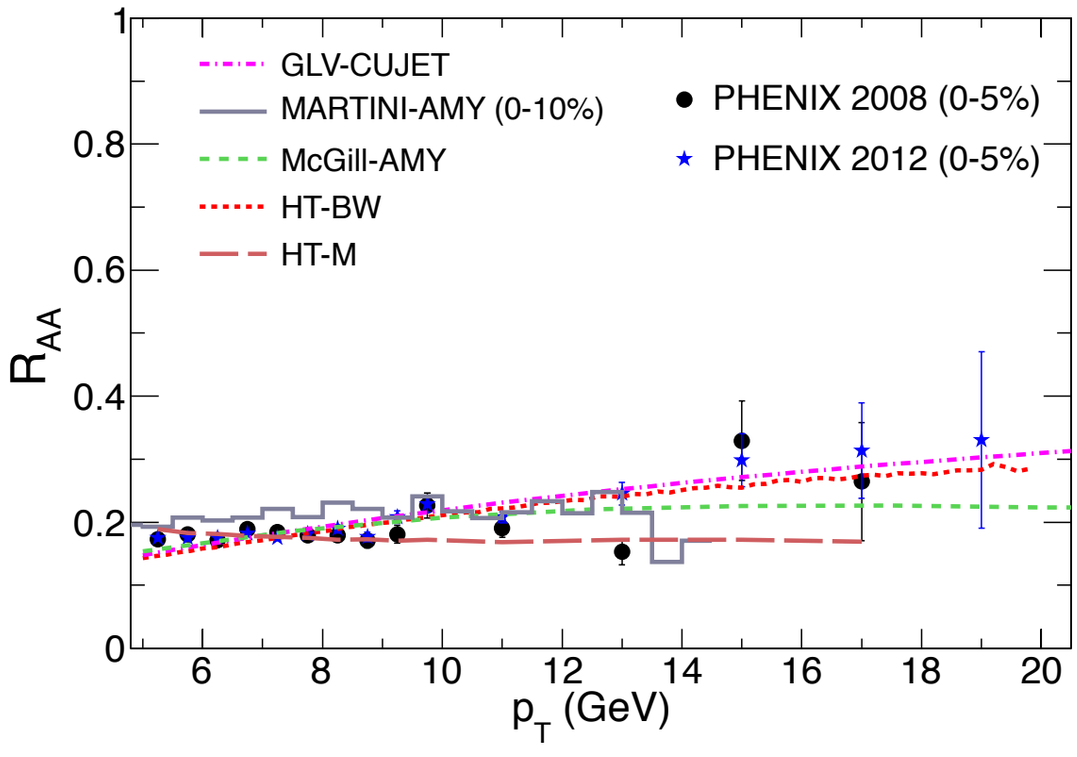
Xin-Nian Wang

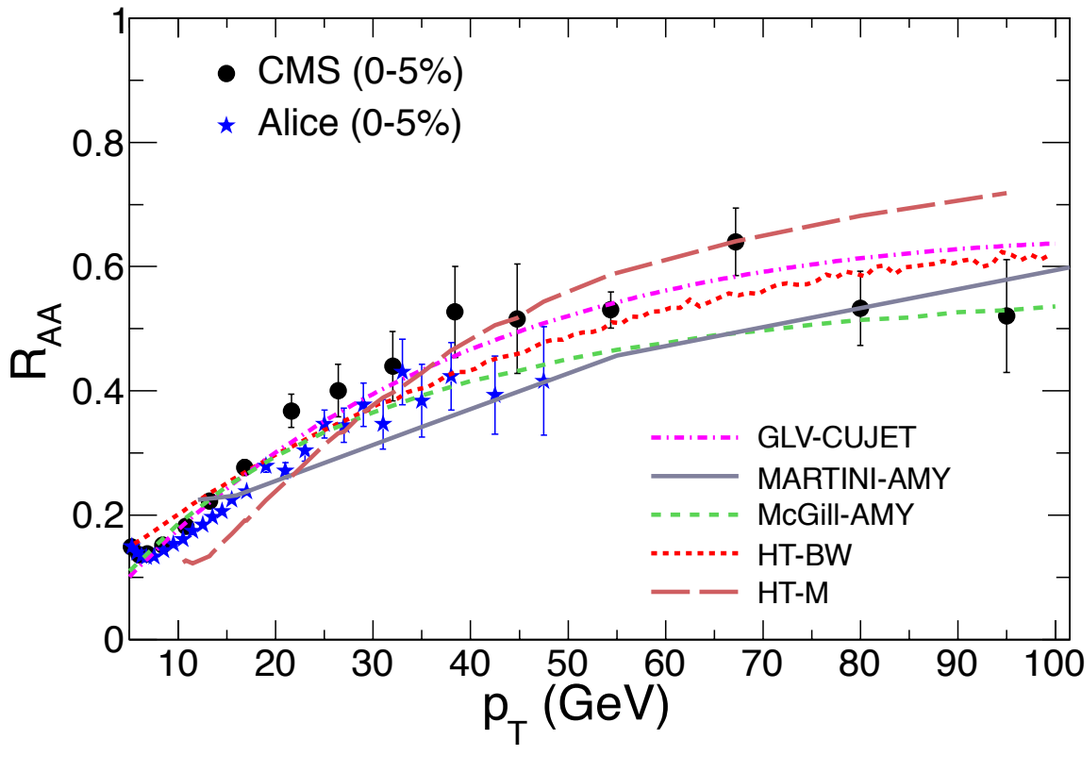
CCNU & LBNL

4th and 5th Year

Scientific Goals\ Timeline of activities	Year 4	Year 5
Develop a general framework and numerical implementations of different approaches to jet modification in a medium, incorporating elastic and radiative energy loss, flavor conversion, quark mass dependence (heavy quarks) and exact four-momentum conservation. Develop Monte Carlo simulation codes in the form of Open Source Codes and Algorithmic Routines (OSCAR) and make them available to the entire heavy-ion community Calculate direct γ production within NLO pQCD, including effects of parton energy loss, induced γ bremsstrahlung and γ conversion, thermal emission from QGP and hadronic phases. Calculate jet and high-p_T hadron spectra, multi-hadron and γ-hadron correlations, and jet shape within NLO pQCD and their medium modification in high-energy heavy-ion collisions. Carry out systematic and quantitative phenomenological studies of experimental data on jet and electromagnetic tomography to extract properties of the sQGP, such as jet transport parameter, shear viscosity, initial temperature and screening mass of the medium.	Develop the Jet and Electromagnetic Tomography (JET) program packages of Monte Carlo simulation of jet propagation and evolution in the form of Open Source Codes and Algorithmic Routines (OSCAR) for use in phenomenological analyses of experimental data. Complete the integration of the parton recombination model with parton energy loss in dynamic medium as described by the hydro-cascade model to calculate hadron spectra in the full range of transverse momentum. Use the resulting modified fragmentation functions to calculate single and dihadron spectra and gamma-hadron correlation in NLO pQCD. Conduct phenomenological studies of the available data (both RHIC and LHC) on large transverse momentum hadrons, dihadron and gamma-hadron correlations, direct photon, heavy quarks and jet shape within the framework developed.	Complete comprehensive phenomenological analyses of the available experimental data on various hard and EM probes from RHIC and LHC using the JET program packages and establish values of the medium properties (such a jet transport parameter, temperature and shear viscosity) and their space-time profile with both theoretical and experimental error bands. Ready the JET program package for release to the public domain for use both in RHIC and LHC experiments.

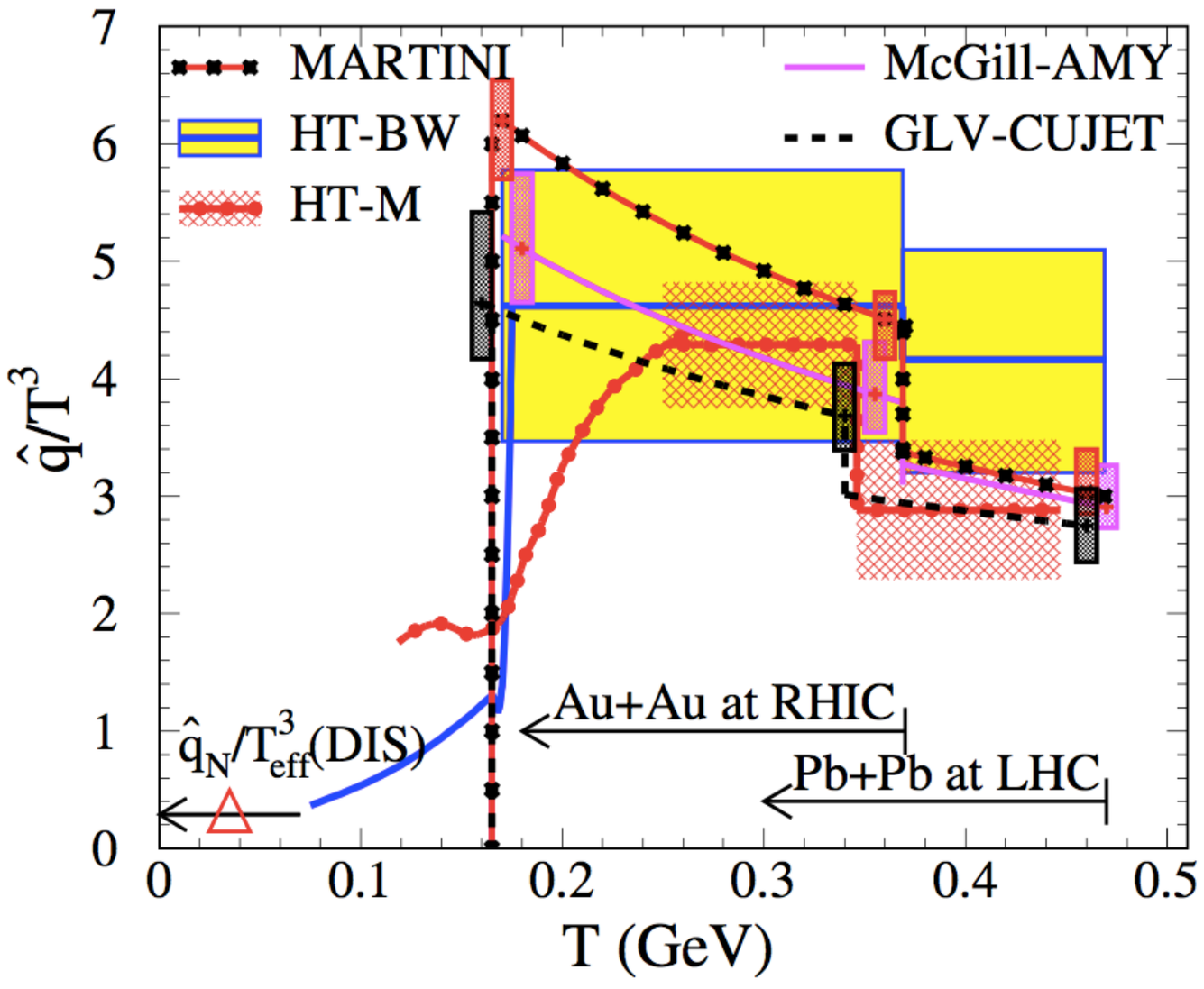
pQCD package and application





Jet transport coefficient

JET Collaboration: **arXiv:1312.5003**



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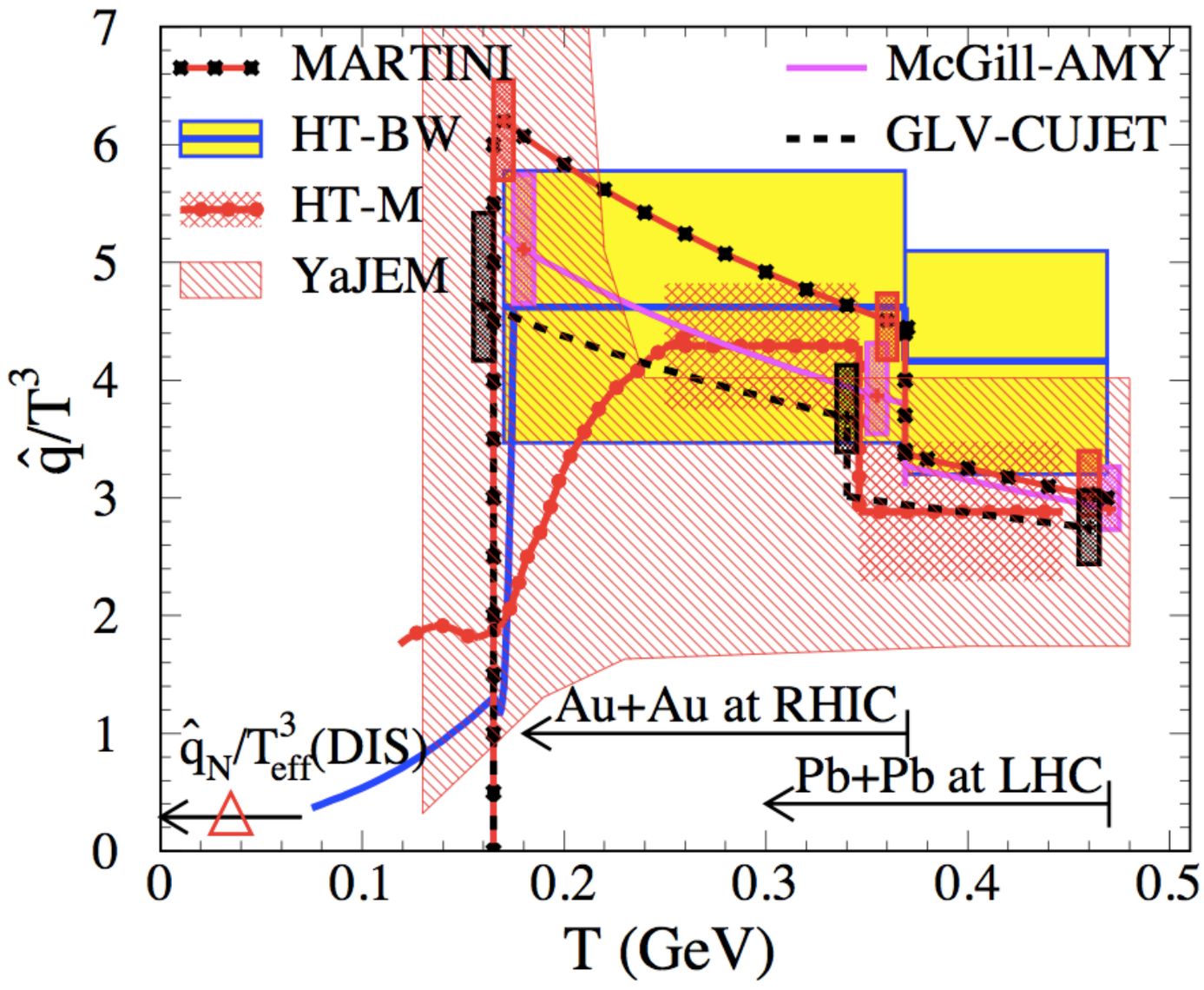

Jet transport coefficient

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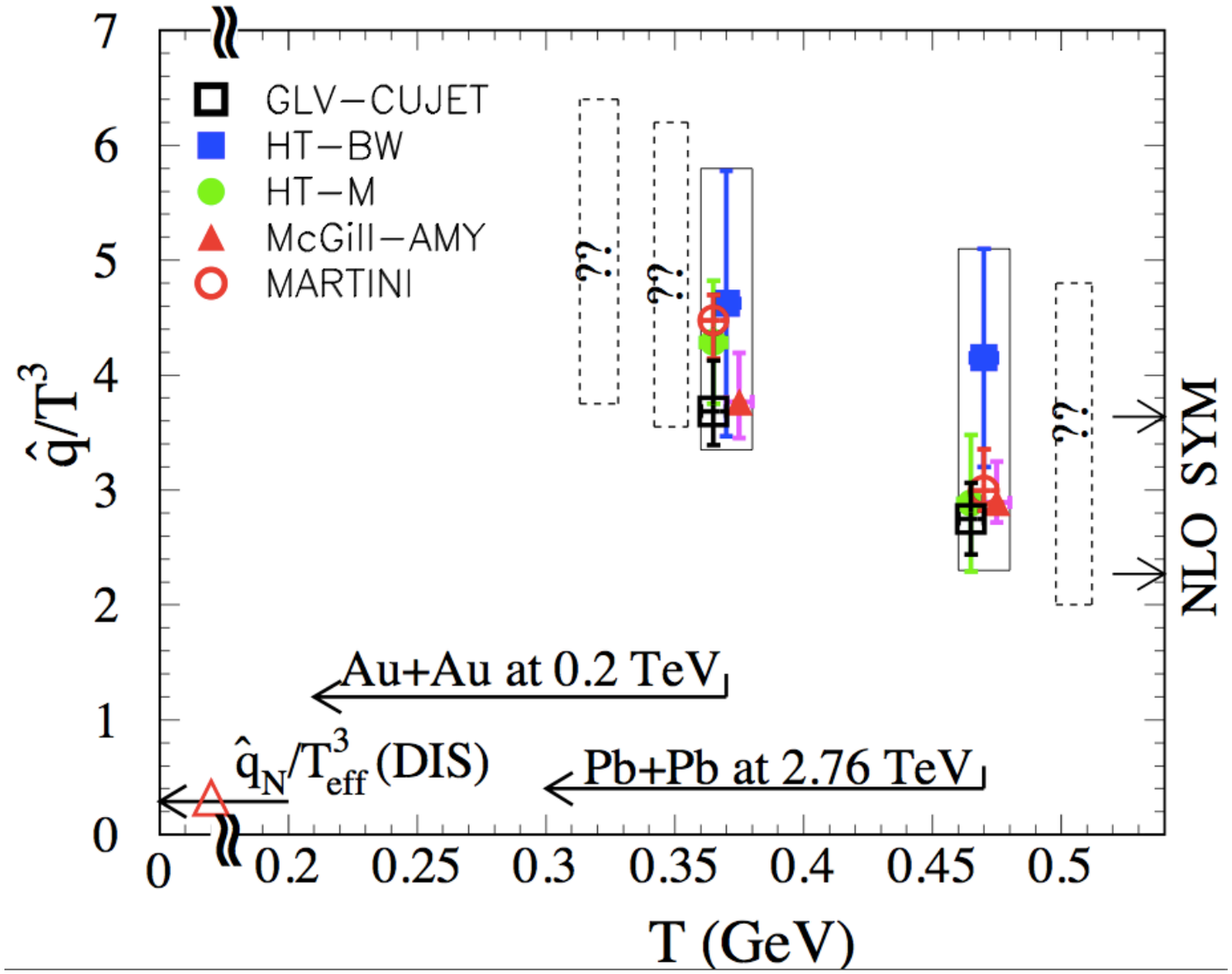


Future: dihadron, gamma-hadron, flavor dependence, jet observables
RHIC BES and LHC higher energy

Other progress in 2013

- NLO pt broadening and GDLAP evolution of qhat (Hongxi's talk)

- Coordinated p+Pb predictions (Ramona's talk)

- Viscous anisotropic hydro (Mike and Ulrich's talks)

Towards our final goal

- Package and publish pQCD program

- Test and finish MC programs: CUJET,LBT, M-HT, MARTINI (see Abhijit's talk)

- Test recombination program and combine with MC (see Rainer's talk)

- Fast Hydro ? (Mike and Paul's talk)

JET Collaboration Meeting

Columbus, June 10-12, 2013

Progress report from LBNL/CCNU

Hydro: Loggang Pang, Wei Chen,
Linear Boltzmann: Yan Zhu, Tan Luo, Yayun He
Jet quenching: A. Buzzatti, H. Zhang

Xin-Nian Wang

CCNU & LBNL

Linear Boltzmann Jet Transport

Linear Boltzmann transport

$$p_1 \cdot \partial f_1(p_1) = -\int dp_2 dp_3 dp_4 (f_1 f_2 - f_3 f_4) \left|M_{12\to 34}\right|^2 (2\pi)^4 \delta^4(\sum_i p_i),$$

$$f_i(p) = (2\pi)^3 \delta^3(\vec{p}_i - \vec{p}_0)\delta^3(\vec{x} - \vec{x}_0 - t\vec{v}_i)[i = 1, 3]$$

$$f_i(p_i) = \frac{1}{e^{p_i \cdot u/T} \pm 1}(i = 2, 4)$$

$$\frac{d\sigma}{dt} = |M_{12\to 34}|/16\pi^2 s^2$$

Li, Liu, Ma, XNW & Zhou（2010）

Linear Boltzmann Jet Transport

Complete elastic scattering processes:

- The total scattering rate for a hard parton i is defined as

$$\Gamma_i = \sum_{j,(kl)} \Gamma_{ij\to kl} = 1/\lambda_0 \qquad P(\Delta t) = 1 - e^{-\Gamma_i \Delta t} \qquad P(ij \to kl) = \frac{\Gamma_{ij\to kl}}{\Gamma_i}$$

- The total scattering rate for a gluon

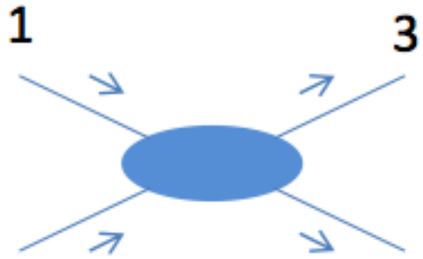
$$\Gamma_g = \Gamma_{gg\to gg} + \Gamma_{gg\to q\bar{q}} + \Gamma_{gq\to gq+g\bar{q}\to g\bar{q}}$$

- The total scattering rate for a quark

$$\Gamma_{q_i} = \Gamma_{q_i g\to q_i g} + \Gamma_{q_i q_j\to q_i q_j} + \Gamma_{q_i q_i\to q_i q_i} + \Gamma_{q_i \bar{q}_i\to q_j \bar{q}_j} + \Gamma_{q_i \bar{q}_i\to q_i \bar{q}_i} + \Gamma_{q_i \bar{q}_i\to gg}$$

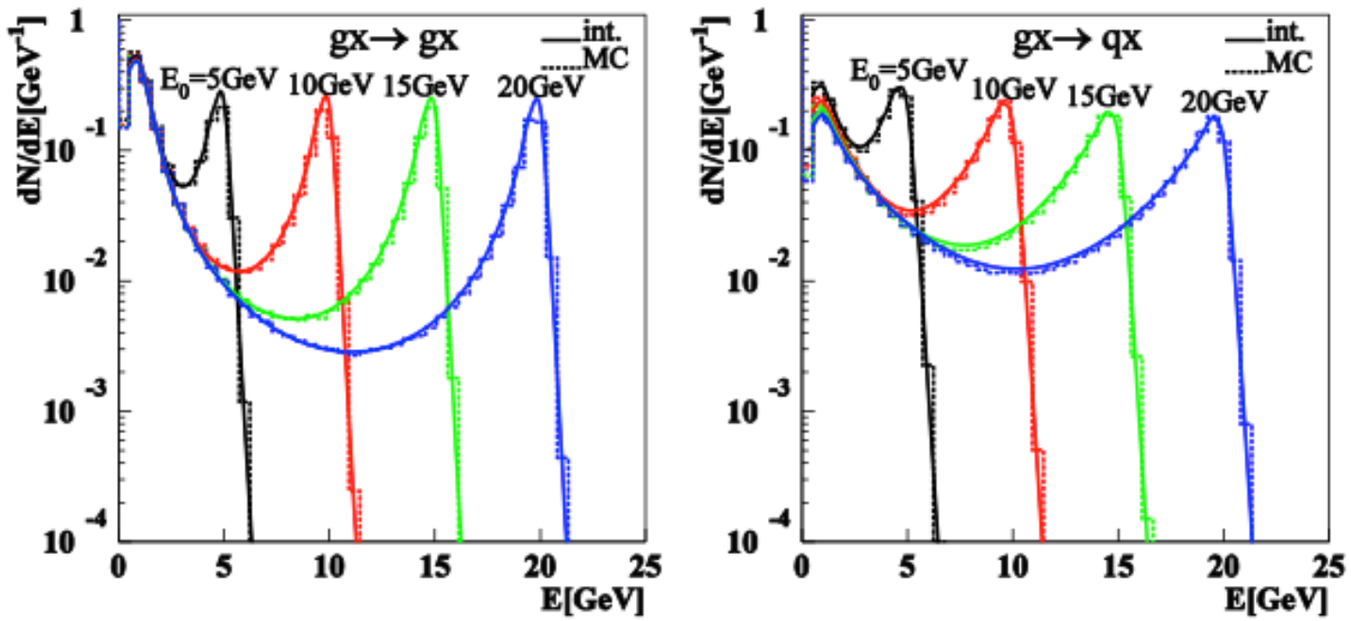
Linear Boltzmann Jet Transport

Systematic check:



the selection of the jet parton

T=0.2GeV



$gg \to gg$

$gg \to q\bar{q}$

$gq \to gq + g\bar{q} \to g\bar{q}$

$q_i g \to q_i g$

$q_i q_j \to q_i q_j$

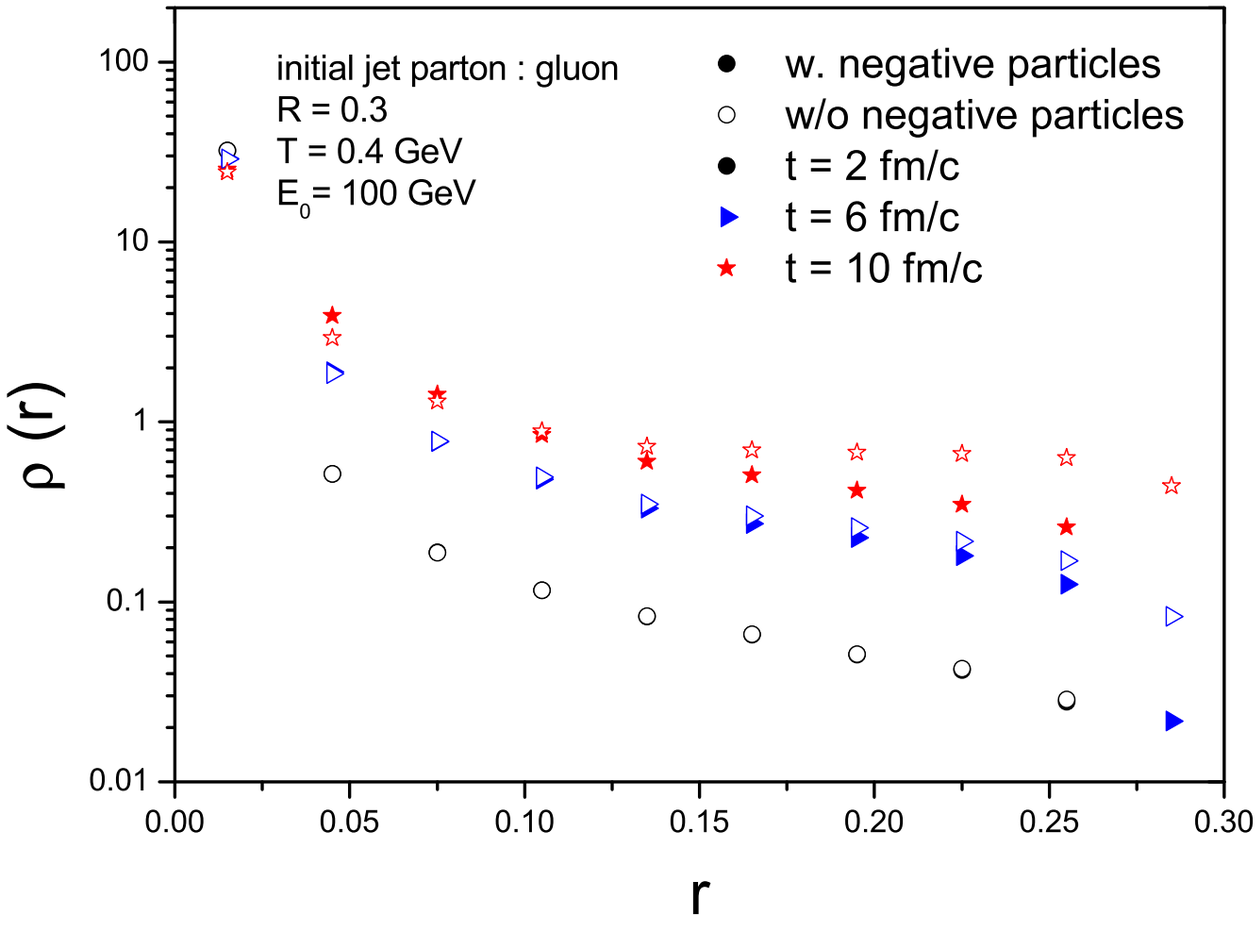
$q_i q_i \to q_i q_i$

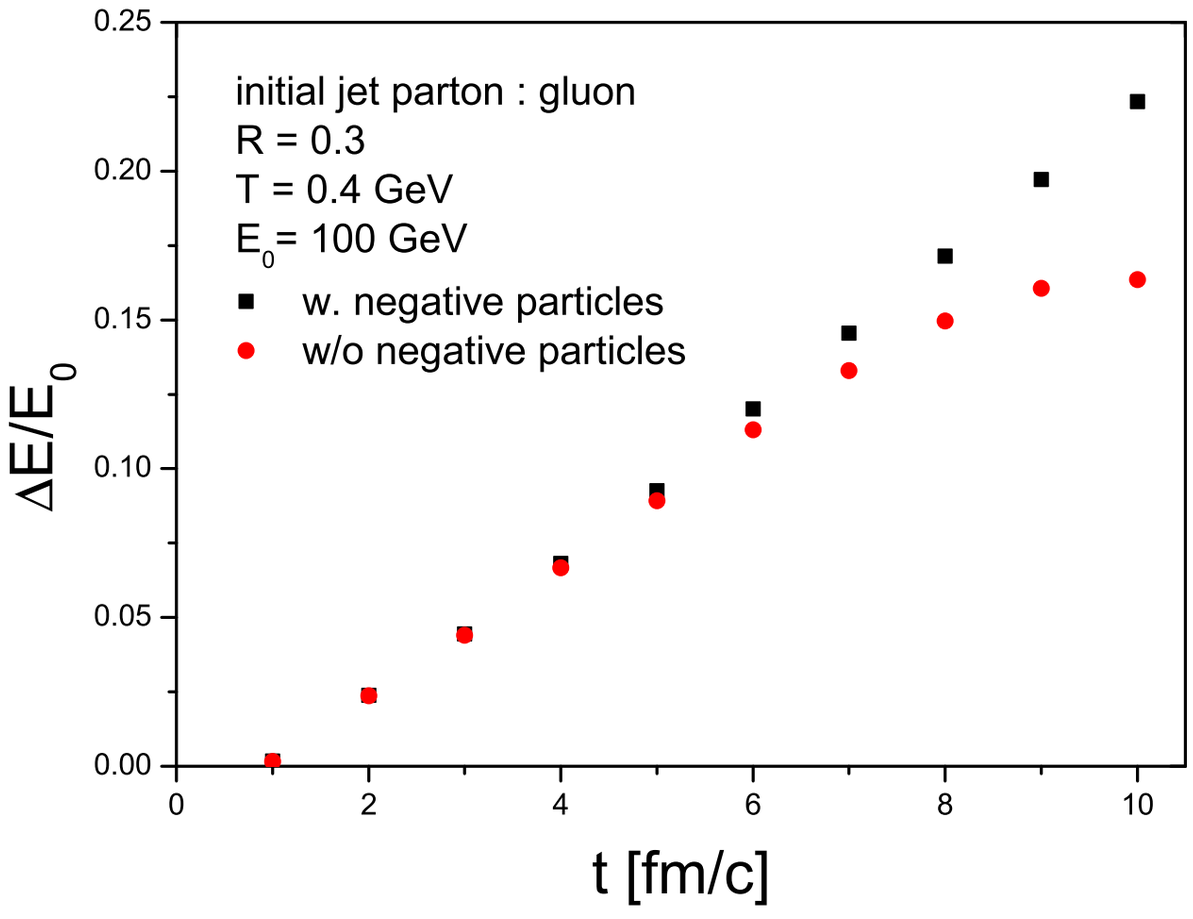
$q_i \bar{q}_i \to q_j \bar{q}_j$

$q_i \bar{q}_i \to q_i \bar{q}_i$

$q_i \bar{q}_i \to gg$

Influence of medium (wake) excitation





Linear Boltzmann Jet Transport

Implement HT induced radiation

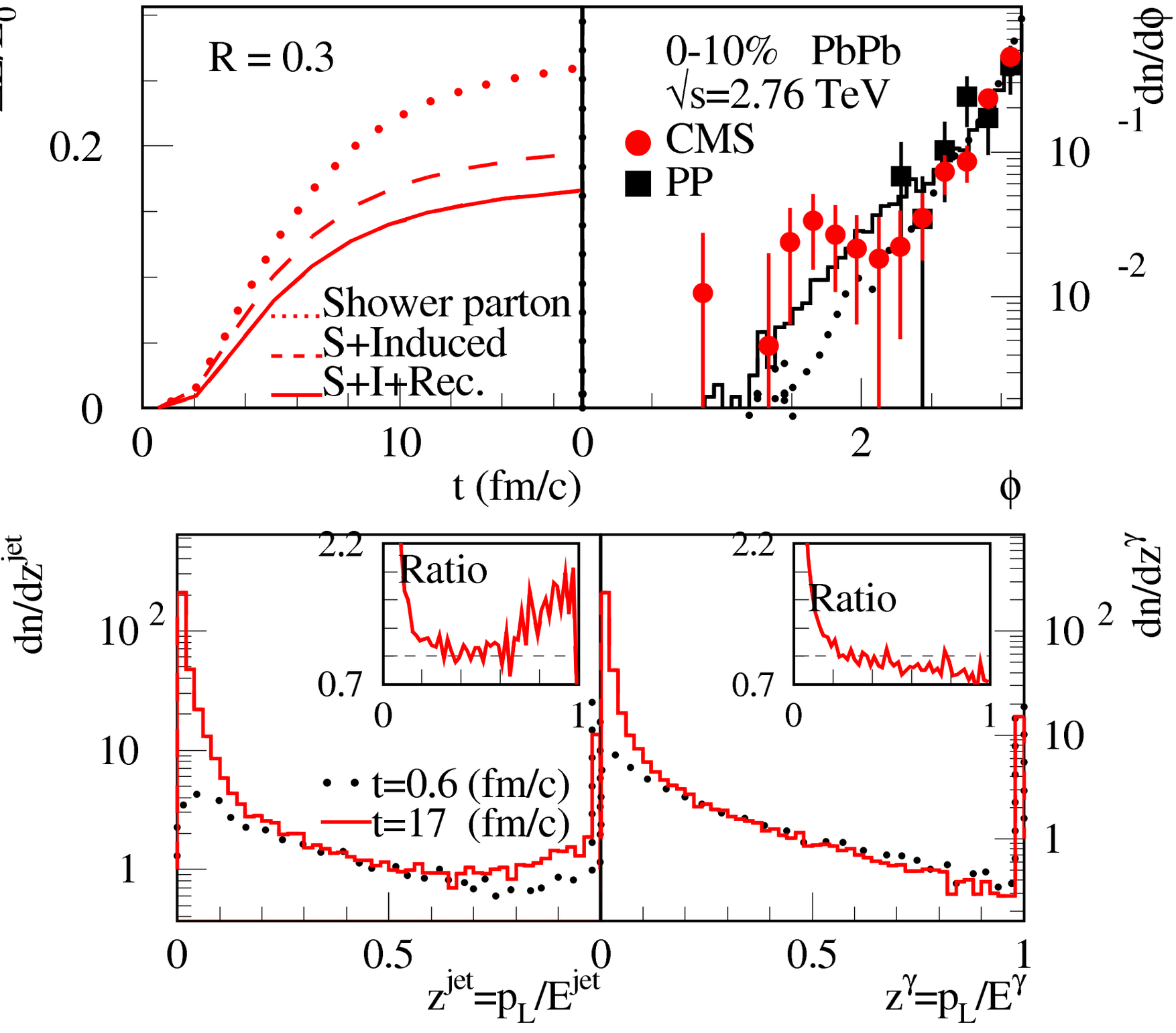
$$\frac{dN_g}{dxdk_\perp^2 dt} = \frac{2C_A\alpha_s P(x)\hat{q}}{\pi k_\perp^4}\sin^2\frac{t-t_i}{2\tau_f},$$

$$P(x) = \frac{1+(1-x)^2}{x}, \quad \tau_f = 2Ex(1-x)/k_\perp^2,$$

$$P(N_g, \langle N_g\rangle) = \frac{\langle N_g\rangle^{N_g} e^{-\langle N_g\rangle}}{N_g!}$$

Probability of radiation and gluon multiplicity for each scattering

Gamma-jet in Pb+Pb Collisions



Current and Future Plans

- Complete LBT model
  - Test coupling to recombination module
  - Complete the MC code for smoothed hydro medium
  - Phenomenological study
- LBT coupled to hydro
  - Jet-induced medium excitations in e-by-e hydro (running parallel)
  - Needs fast hydro

Issues to discuss

- Complete the final MC package

- Future of JET Collaboration

- Symposium next year to celebrate JET's 5 year achievements

- JET final report to DOE