Dynamics of thermalized and non-thermalized particles in relativistic heavy-ion collisions

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Collaborators

Hydro+Jet

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Early chemical freeze-out

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HBT

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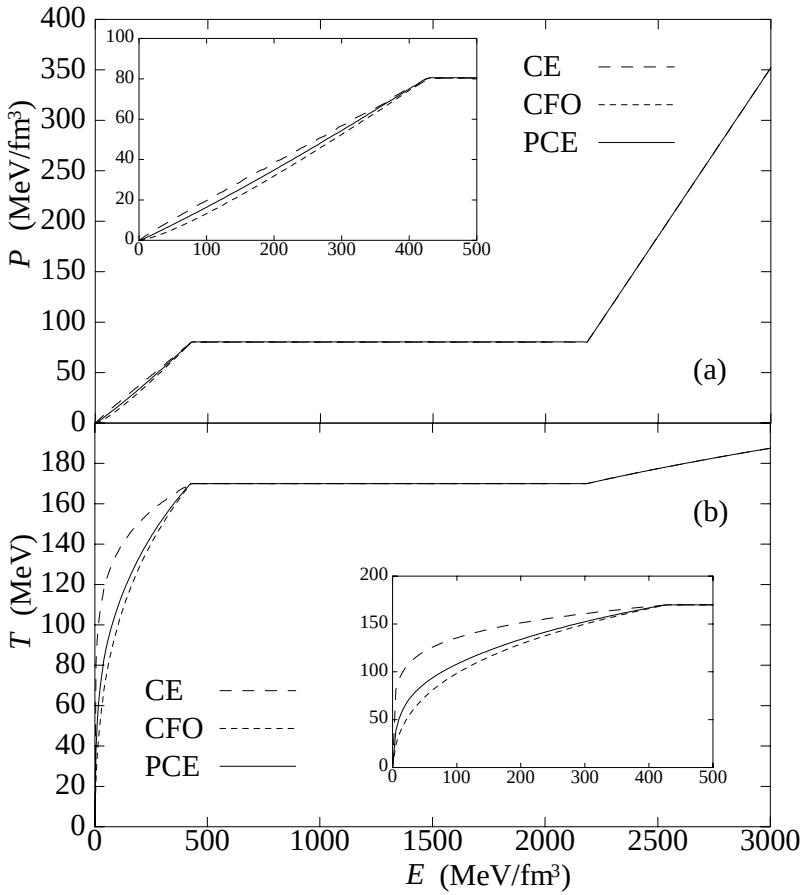
Motivation

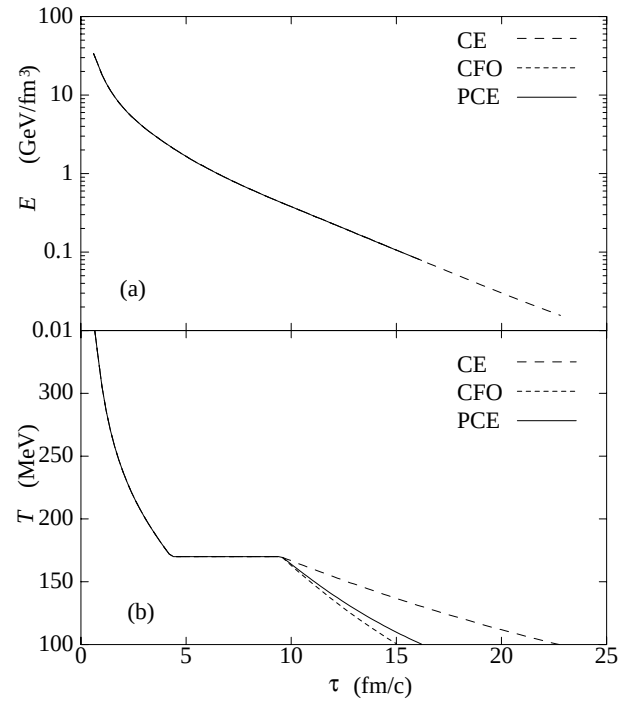
We want to describe in detail the whole stage of relativistic heavy-ion collisions within *one* model.

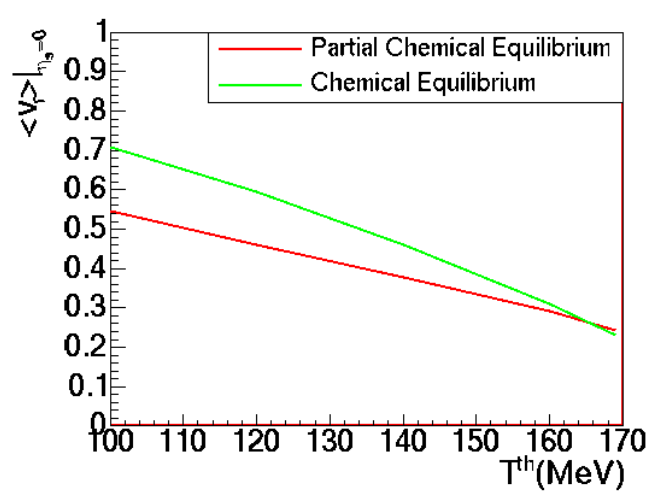
→ Systematic ("orthodox") approach to the search for QGP in HIC

1. From QGP (high T) to hadrons (low T)
   - Phase transition, expansion, etc. →hydrodynamics
2. From midrapidity to forward/backward rapidity
3. From central to non-central collisions
   - No spatial symmetries → Full 3D simulations
4. From soft (low p_T) to hard (high p_T)
   - Interaction between matter and 'jets' →hydro+jet
5. From low energy (AGS,SPS) to high energy (RHIC,LHC)
   - …

Topics 1: Early chemical freeze-out

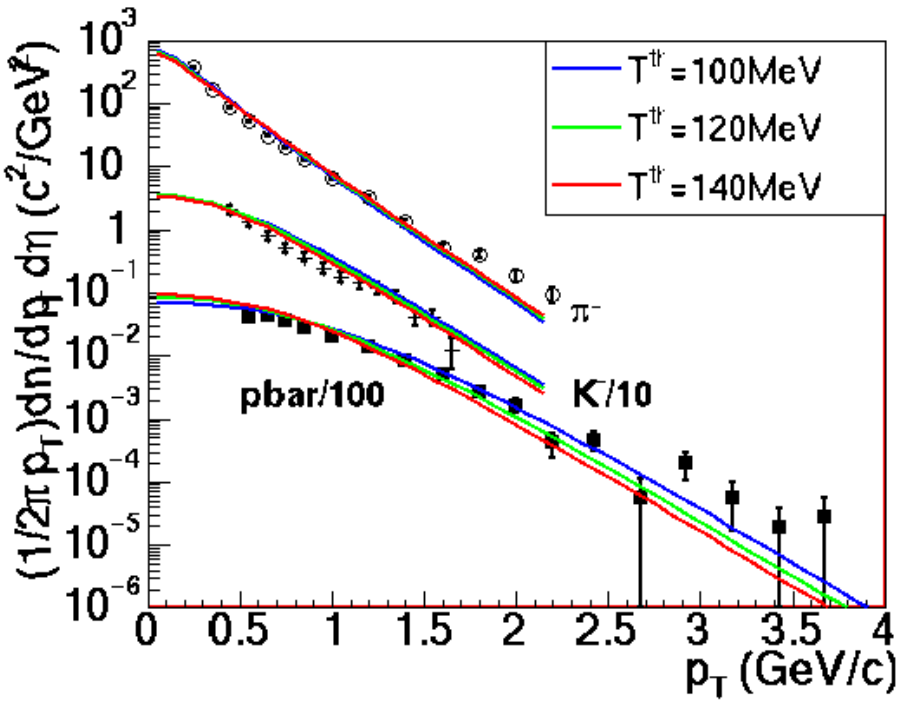


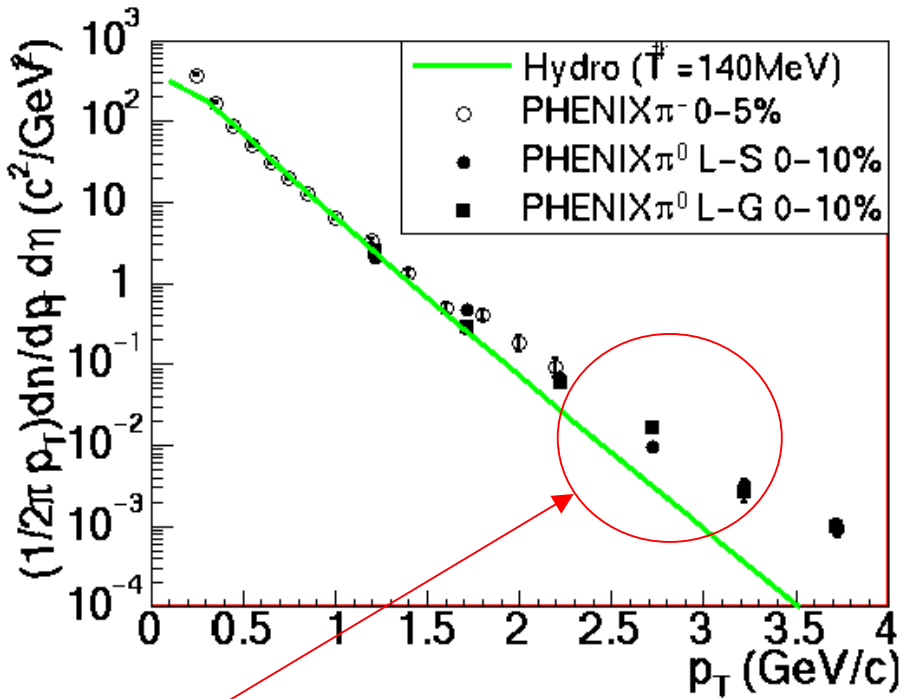




Resonance population in the chemically frozen system is larger than in the equilibrated one.
→Effects on hydrodynamic behavior?

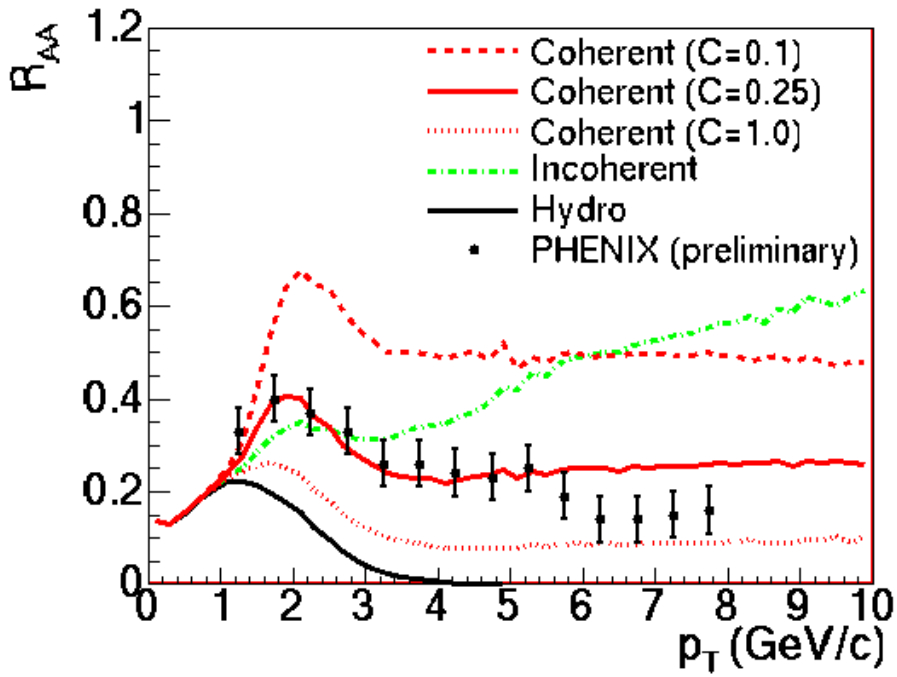
Topics 1: Early chemical freeze-out (contd.)

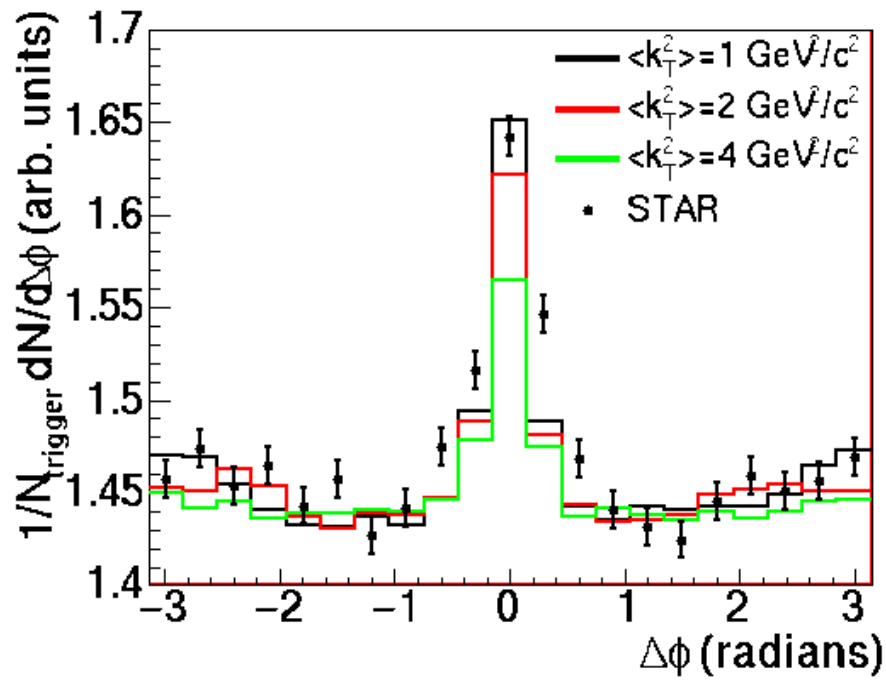




Need hard components?

Topics 2: Hydro+Jet (b-to-b)





$$R_{AA}(p_T) = \frac{dN^{AA}/dp_T}{\langle N_{\text{coll}} \rangle dN^{pp}/dp_T}$$

GLV formula:

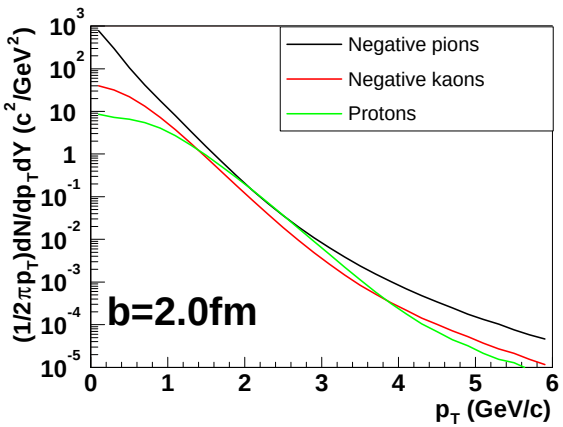
$$\Delta E = C \int_{\tau_0} d\tau (\tau - \tau_0) \rho \ln \left(\frac{2E}{\mu^2 L} \right)$$

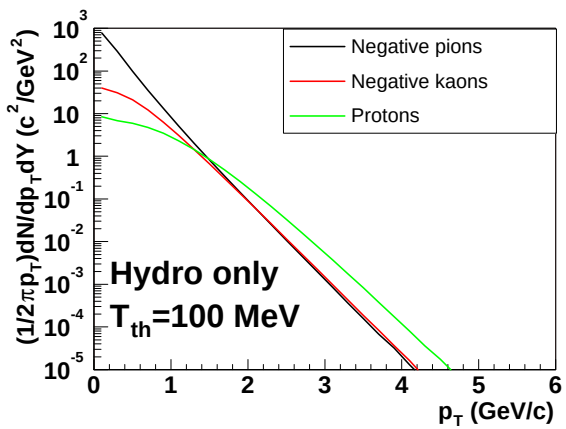
Three effects:

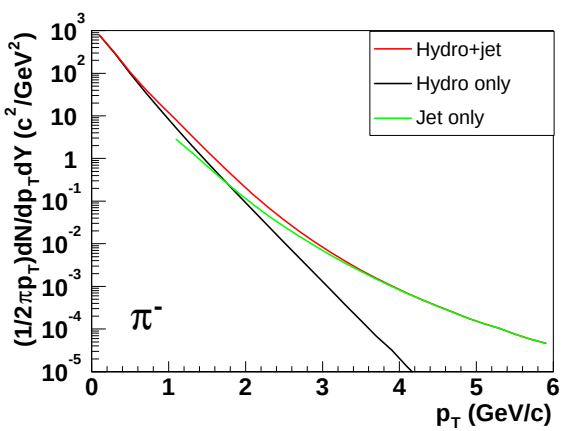
- Energy loss
- Intrinsic k_T
- $p_\perp$ broadening

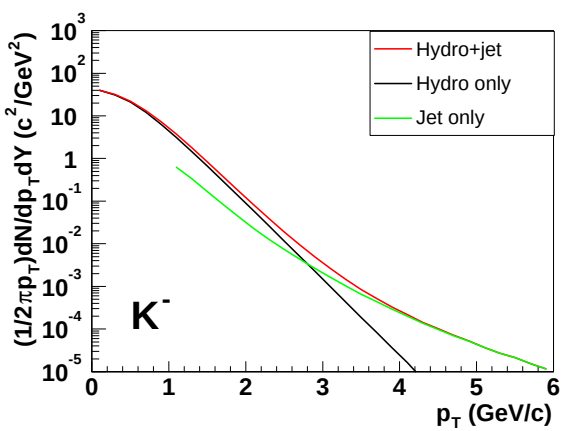
→Disappearance of b-to-b

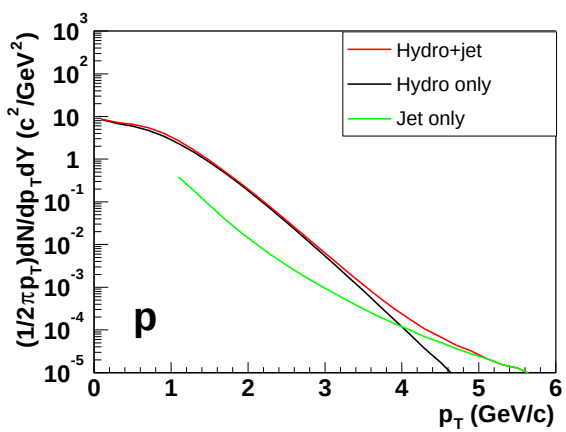
Topics 2: Hydro+Jet (transverse dynamics)







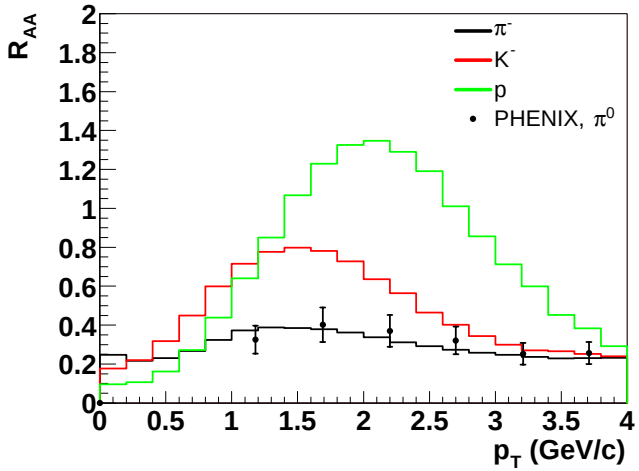


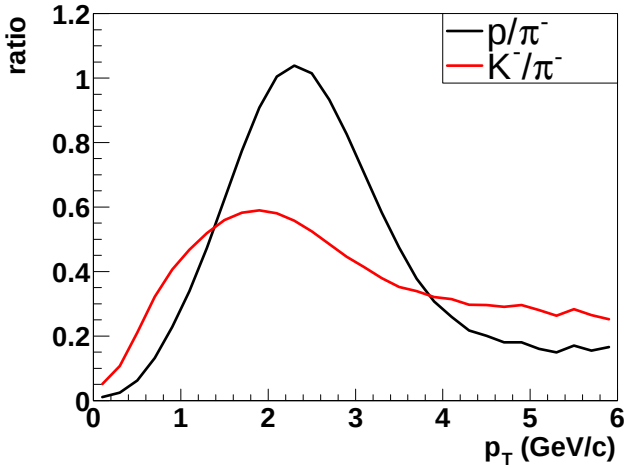


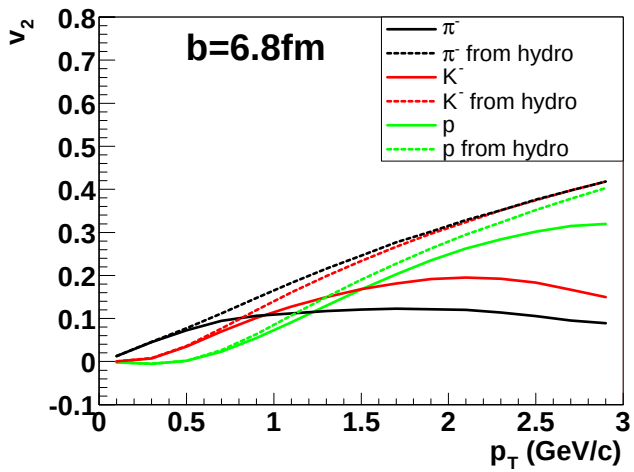
$$p_{T,\mathrm{cross}} \begin{cases} \pi & \sim & 1.6\mathrm{GeV}/c \\ K & \sim & 2.8\mathrm{GeV}/c \\ p & \sim & 4.0\mathrm{GeV}/c \end{cases}$$

Interplay between radial flow and jet quenching

Topics 2: Hydro+Jet (transverse dynamics)(contd.)







Interpretation of puzzles:

- R_{AA} ~1 for protons
- p/π ~ 1
- Crossing of v_2

  Just radial flow

  (+jet quenching)

Hadronic observables from hydro+jet

Rapidity distribution
p_T spectra
Correlation function (HBT radii)
Ellitpic flow parameter v_2
Particle ratio *
Suppression factor R_{AA}
Correlation function for high p_T hadrons
…

Directed flow v_1 ???
Fluctuation ???

* Need baryon chemical potential in EoS

Outlook

Early chemical freeze-out

•Inclusion of baryon chemical potential into chemical non-equilibrium EoS

→Analyses @ SPS energies

Hydro+jet

•Centrality dependence of R_{AA}, monojets, v_2,…

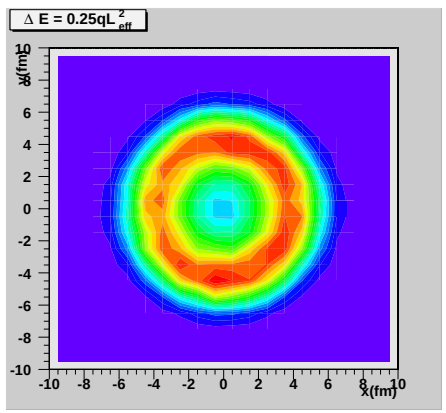
•Rapidity dependence of R_{AA}

•Jet quenching at SPS

•Prediction of R_{AA} and monojets @ LHC

•Hydro+jet+(hadronic-)cascade?

→Interpretation of HBT puzzle (R_{side}~R_{out})?



Paper

- "Interplay between soft and hard hadronic components in relativistic heavy ion collisions (tentative)", T.H. and Y.Nara (in preparation).

- "Back-to-back correlations of high p_T hadrons in relativistic heavy ion collisions", T.H. and Y.Nara, nucl-th/0301042 (Submitted to PRL).

- "Energy loss in high energy heavy ion collisions from the hydrodynamic and jet model", T.H. and Y.Nara, Phys. Rev. C **66**, 041901(2002).

- "Collective flow and two-pion correlations from a relativistic hydrodynamic model with early chemical freeze-out", T.H. and K.Tsuda, Phys. Rev. C **66**, 054905 (2002).

- "Hydrodynamical analysis of hadronic spectra in the 130 GeV/nucleon Au+Au collisions", T.H., K.Morita, S.Muroya, and C.Nonaka, Phys.Rev. C **65**, 061902 (2002).

- "Comparison of space-time evolutions of hot, dense matter in sqrt(s_{NN})=17 and 130 GeV relativistic heavy ion collisions based on a hydrodynamical model", K.Morita, S.Muroya, C.Nonaka, and T.H., Phys. Rev. C **66**, 054904 (2002).

Talk

３月　５日　「極限条件におけるハドロン科学」@原研
３月１５日　Nuclear theory seminar @ BNL
５月２１日　QCD勉強会 @ 理研放射線研理論グループ
６月１５日　Workshop on two-particle interferometry and elliptic flow at RHIC @ BNL (invited talk)
６月２６日　セミナー@都立大素粒子グループ
７月２２日　Quark Matter 2002 @ Nantes, France
９月１３日　日本物理学会@立教大学（招待講演）
１０月　１日　PaNic’02 @ Osaka
１１月　５日　Physics of QCD Many Body Systems @ RIKEN (invited talk)
１２月　６日　セミナー@KEK理論グループ
１月　９日　Joint Workshop on Quarks, Astrophysics, and Space Physics @ Hongo (invited talk)