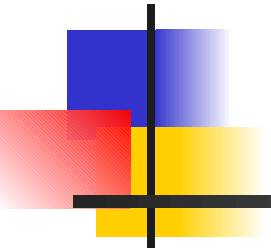
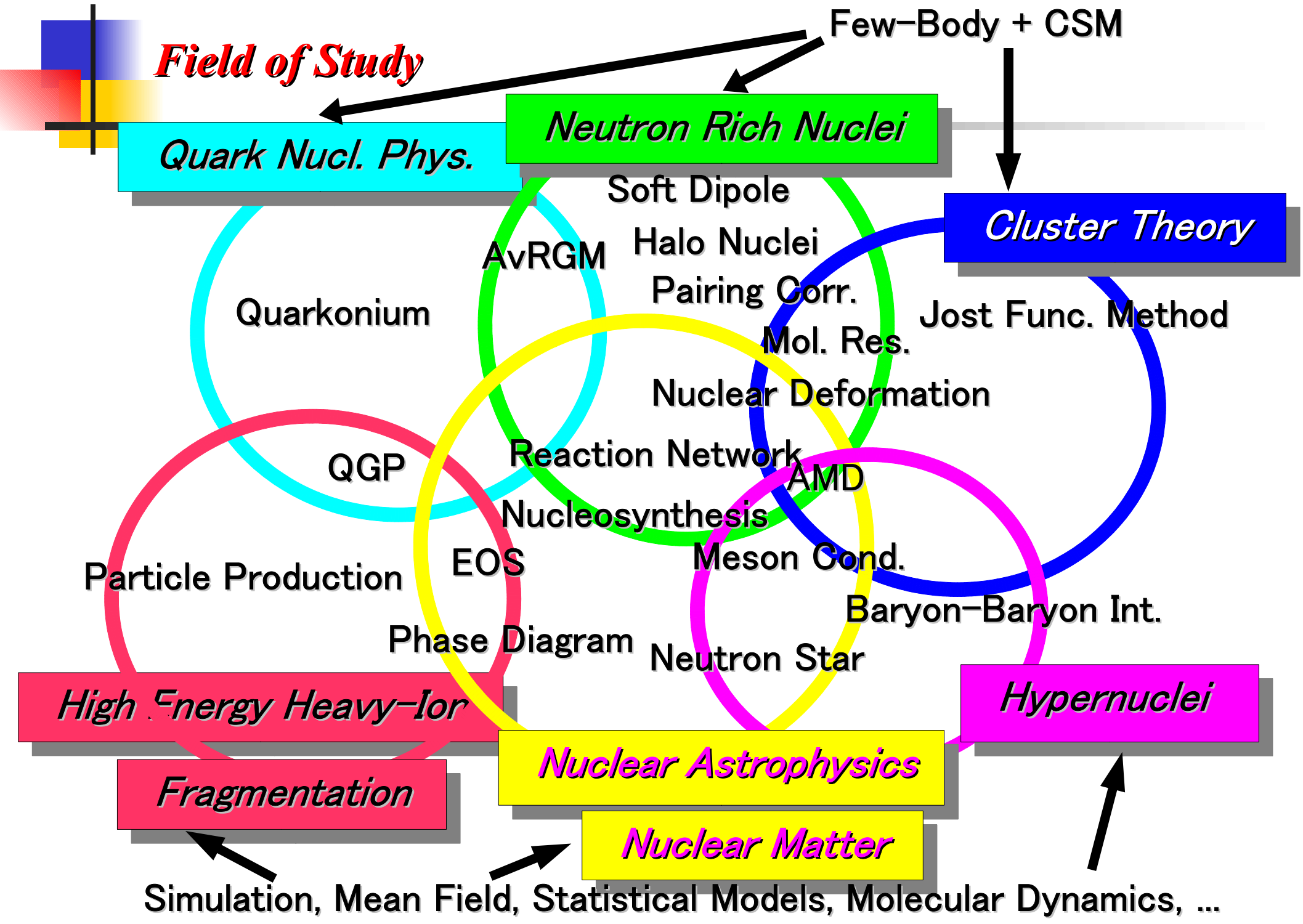
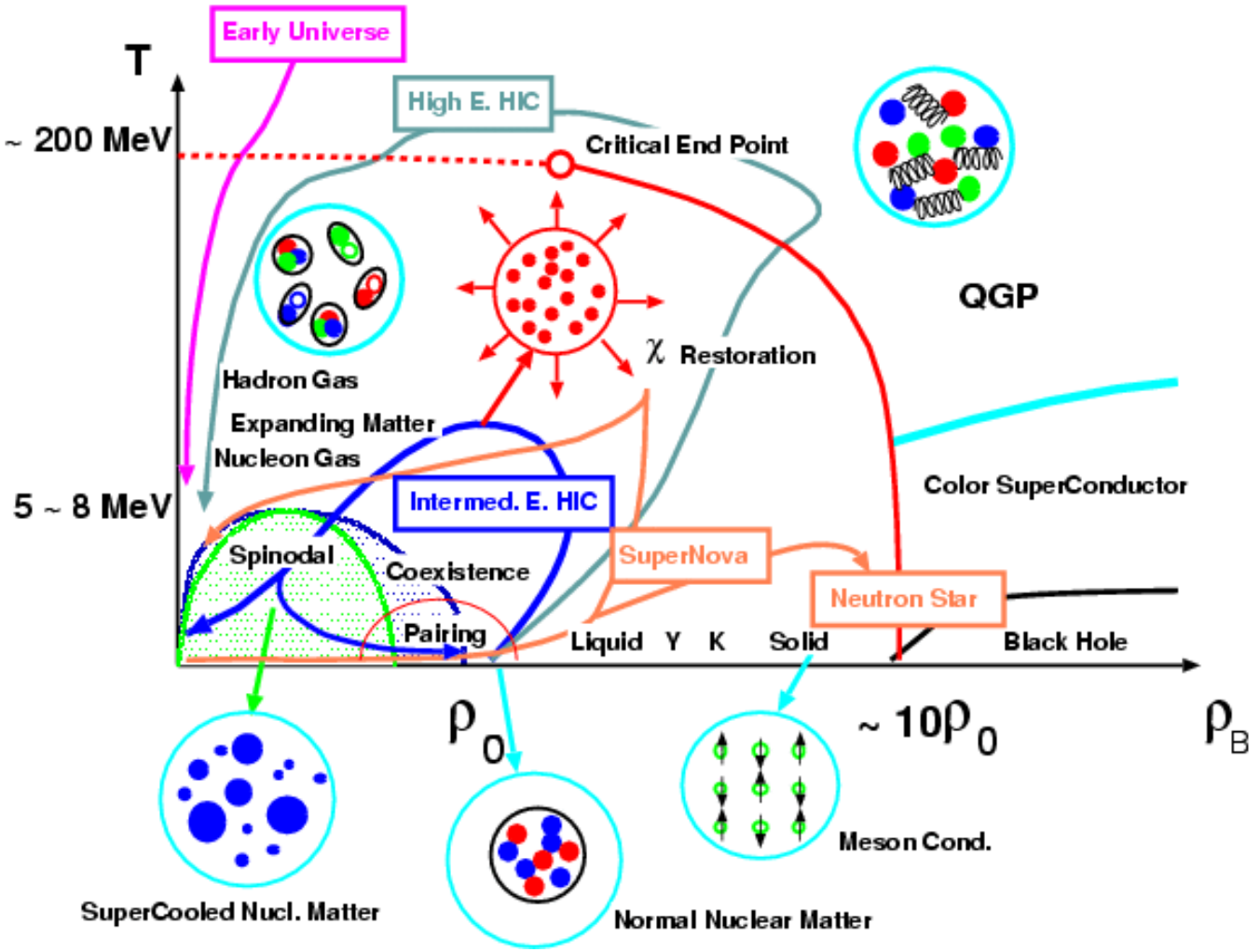


Dynamics of Nuclear and Hadronic Matter

Akira Ohnishi (Hokkaido Univ.)


Field of Study
Few-Body + CSM
Quark Nucl. Phys.
Neutron Rich Nuclei
Cluster Theory
Soft Dipole
Halo Nuclei
AvRGM
Pairing Corr.
Quarkonium
Jost Func. Method
Mol. Res.
Nuclear Deformation
QGP
Reaction Network
AMD
Nucleosynthesis
EOS
Meson Cond.
Particle Production
Baryon-Baryon Int.
Phase Diagram
Neutron Star
High Energy Heavy-Ion
Hypernuclei
Nuclear Astrophysics
Fragmentation
Nuclear Matter
Simulation, Mean Field, Statistical Models, Molecular Dynamics, ...

Hadronic Matter Phase Diagram



Various kind of states, Many things to do, and All of them are related to each other.

Recent Progress in Nuclear, Hadronic and Quark Matter

High Energy Heavy-Ion Collisions

Observation of Jet Energy Loss at RHIC
Collective Motion of Partons (Elliptic Flow)
Kaon Enhancement at SPS

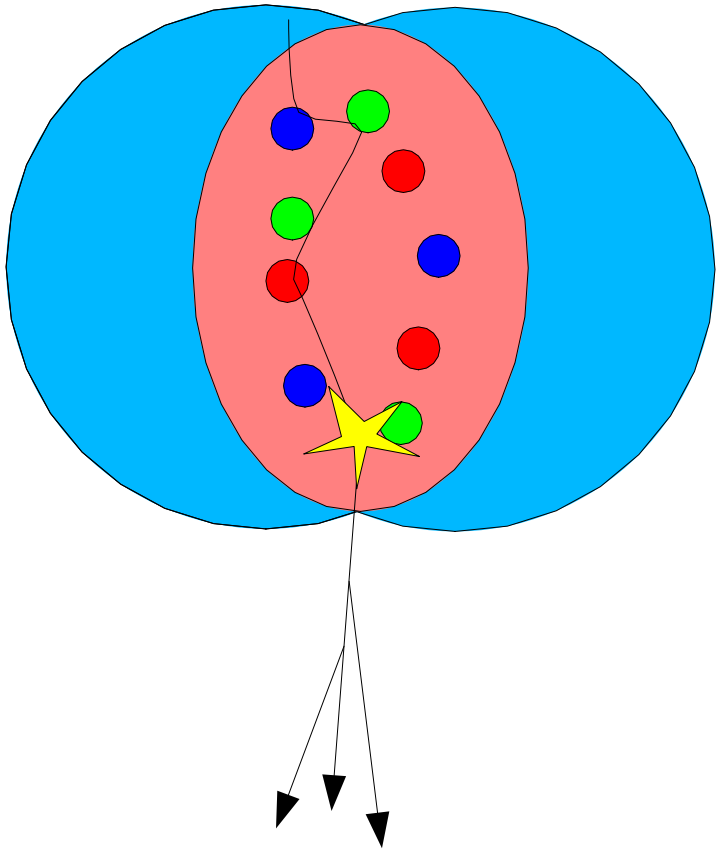
Fragmentation

First order nature of Liquid-Gas Phase Transition
"Isoscaling" of formed fragments
(Additional Effects of Asymmetry in Fragment Yield)

Hypernuclear and Strangeness Nuclear Physics

Discovery of Penta Quark $\Theta^+(uudd\bar{s})$
Discovery of Double Hypernucleus, ${}^{6}_{\Lambda\Lambda}\mathrm{He}$
Discovery of Deeply Bound Kaonic Nucleus
New Puzzle: Σ Potential in Nuclei

Jet Energy Loss at RHIC (I)



6/18 Press Release

Colored partons will lose energy
in colored gas environment (=QGP)

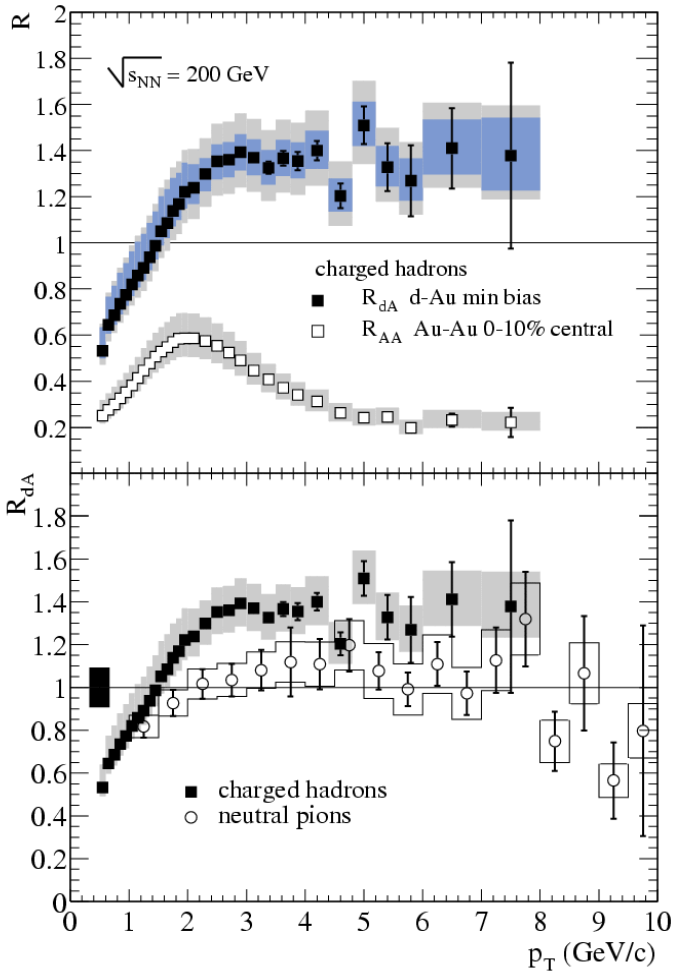
Since High Energy Particles are expected
to come from Jet Fragmentation,
they are suppressed if QGP is formed.

Jet Energy Loss at RHIC (II)

Do we really see suppression of high energy particles at RHIC ?

→ **YES for Au+Au Collisions, and NO for d+Au Collisions !**

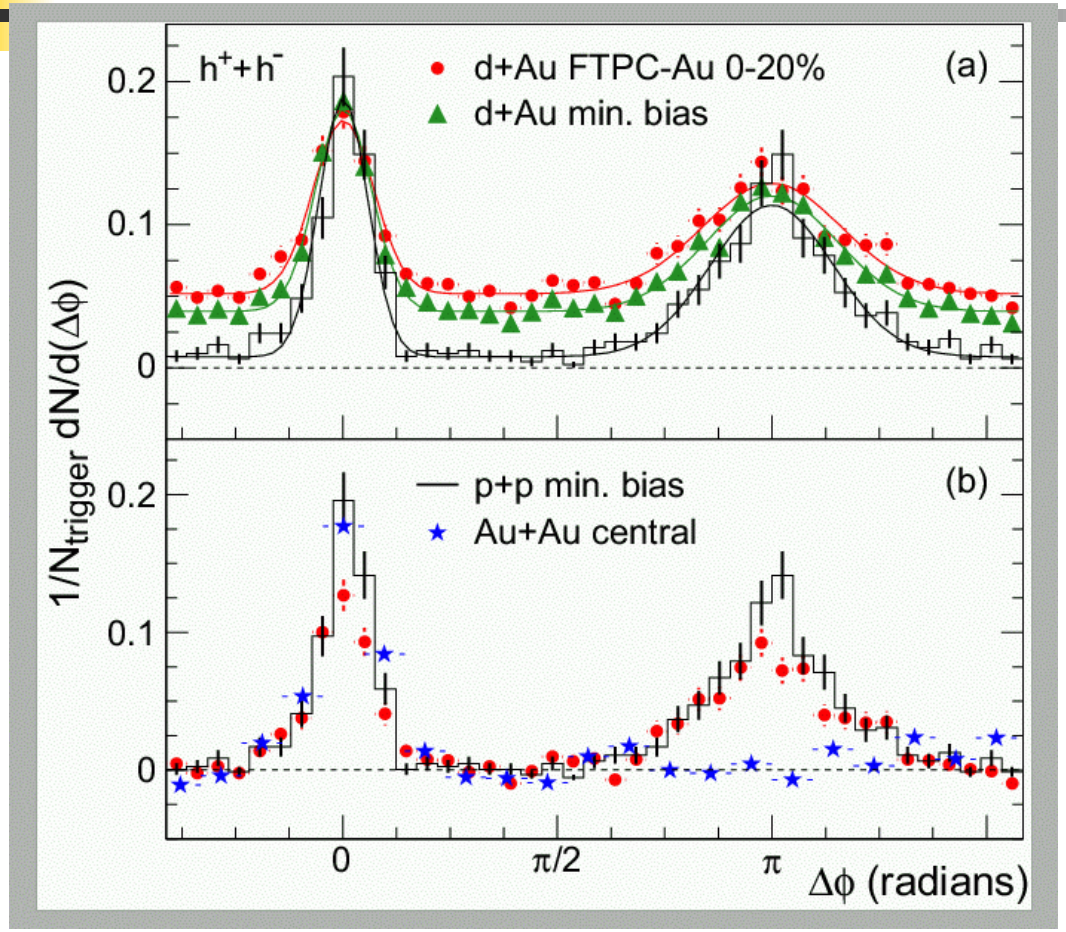
$$R_{AB}(p_T) = \frac{d^2N/dp_T d\eta}{T_{AB}\, d^2\sigma^{pp}/dp_T d\eta}$$

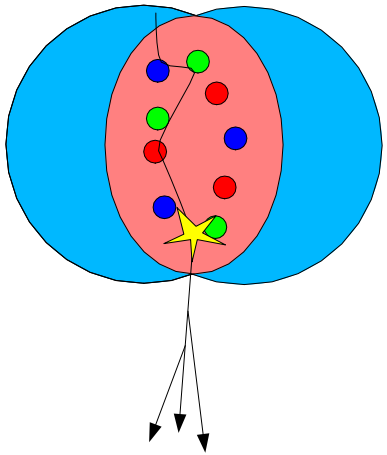


High Energy Particles are suppressed in Au + Au Collisions but NOT suppressed in d + Au Collisions at RHIC compared to p+p collisions !

(PHENIX: nucl-ex/0306021)

Jet Energy Loss at RHIC (III)





STAR (nucl-ex/0306024)

Jet Energy Loss also lead to reduction of back-to-back correlation

Jet Energy Loss at RHIC (IV)

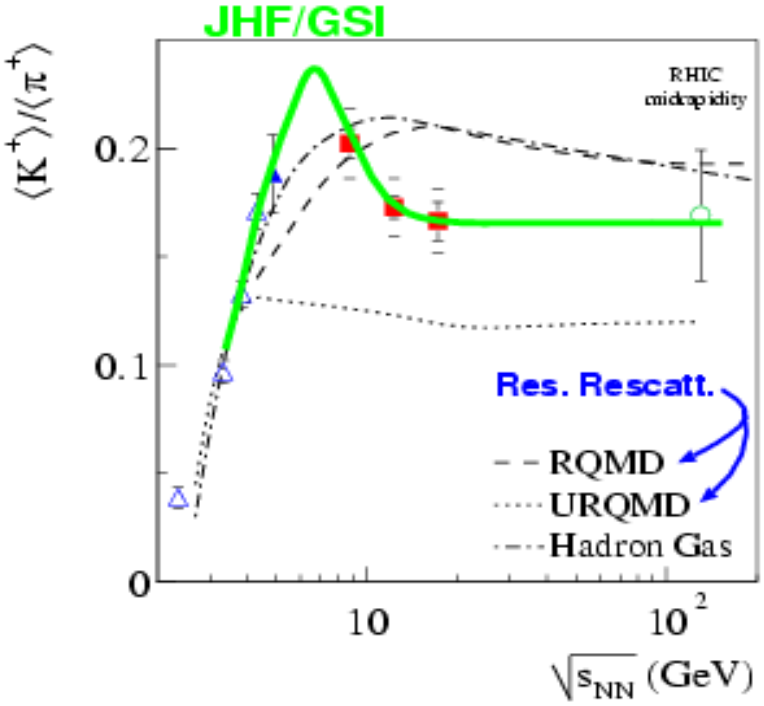
1. High energy particles are suppressed compared to pp collisions at RHIC. Note that it has not been seen at lower energies, e.g. SPS.
2. This high energy particle suppression is not found in d+A collision, where QGP formation is not expected. Thus it is considered to be the final state effect rather than the initial state effect such as the color glass condensate.
3. Back-to-back correlation is also suppressed in Au+Au collisions at RHIC. This is consistent with the Jet Energy Loss scenario of high energy particle suppression.
4. The ratio R_{AA} is calculated by using Glauber model, in which small momentum transfer is assumed.

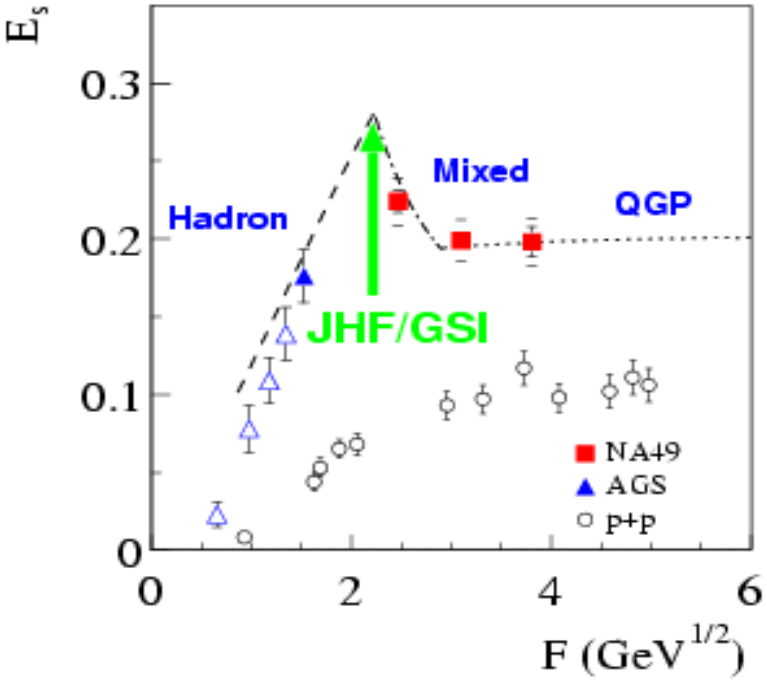
It is very likely that QGP is formed in Au+Au collisions at RHIC. Further confirmation may be necessary.

Strangeness Enhancement: Rescattering, Potential, or Phase Transition ?

Strangeness is Enhanced Sharply at Einc = 10 ~ 40 GeV/A !

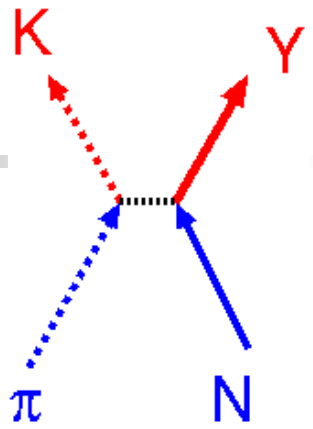
NA49 (nucl-ex/0205002)



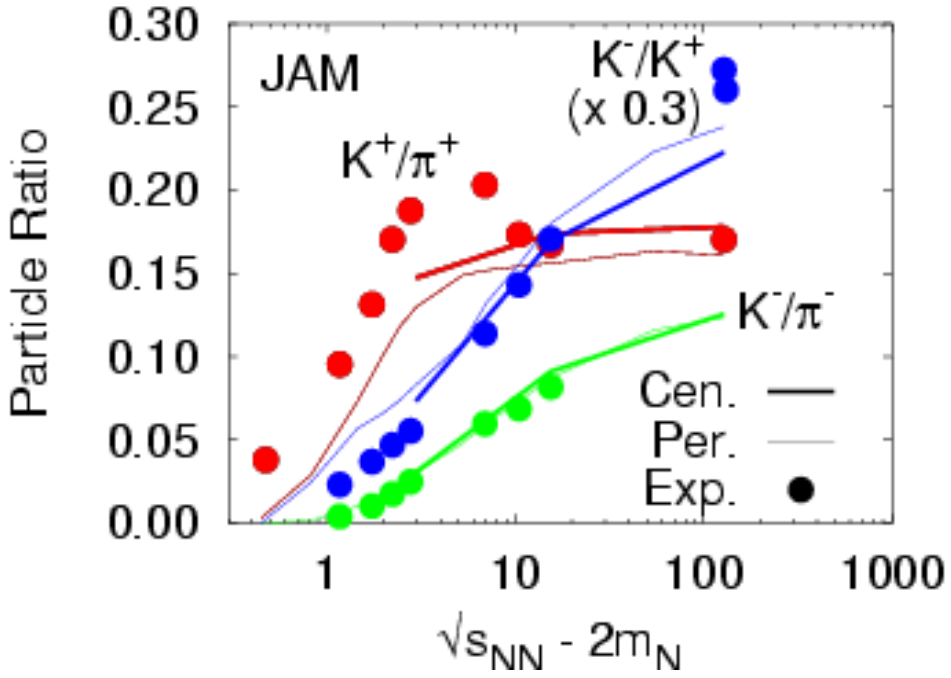


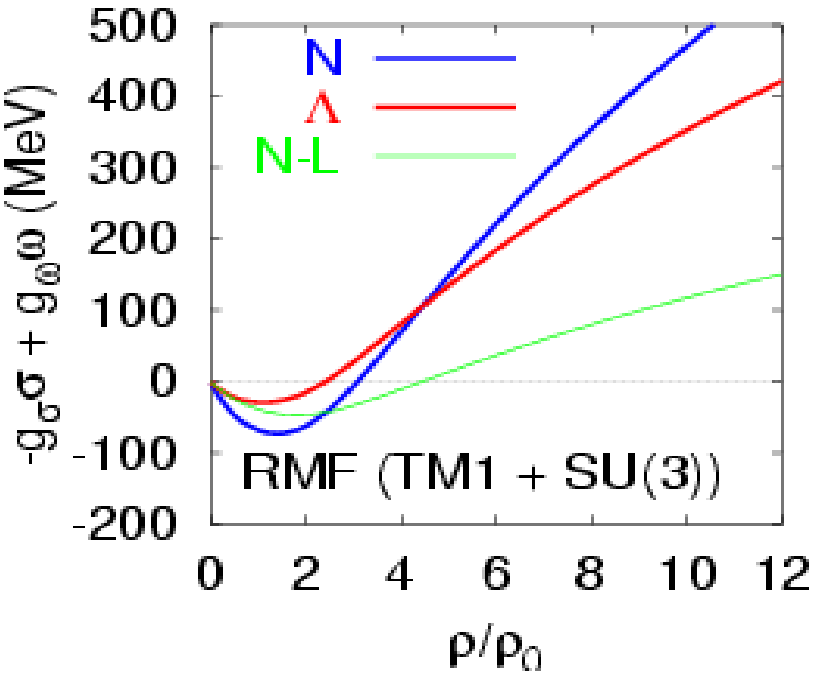
JHF Energy: ~ Maximum K/π ratio

Does Hyperon Potential Help It ?



- Rescattering of Resonances/Strings (RQMD)
- Baryon Rich QGP Formation
- High Baryon Density Effect (Associated Prod. of Y

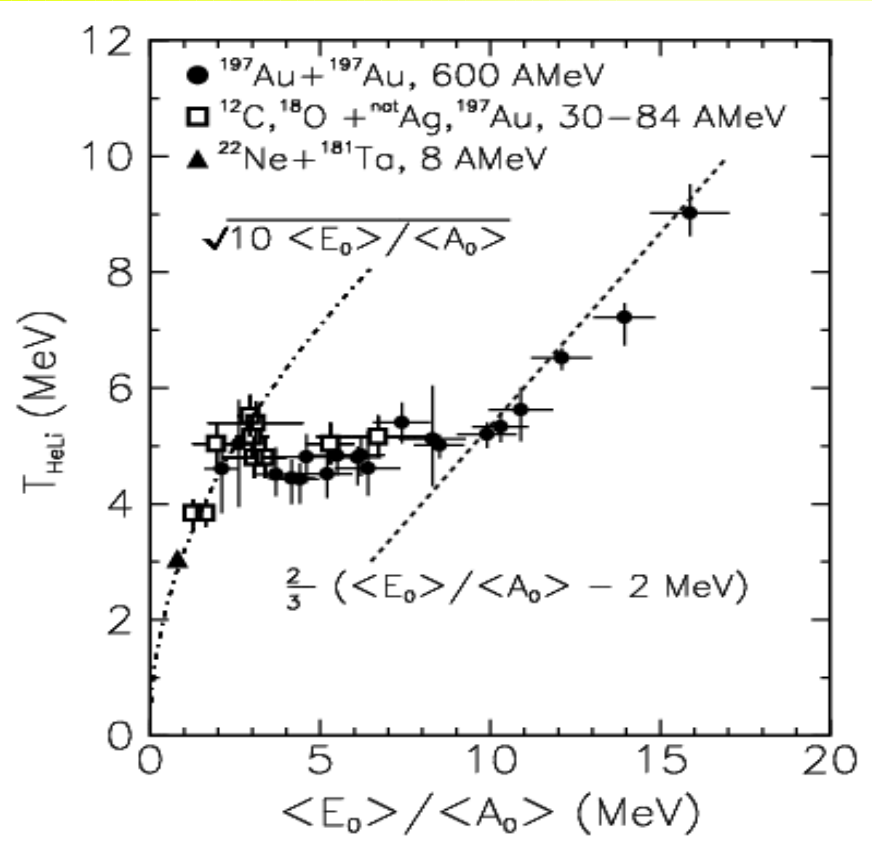




At $\rho > 5\rho_0$ Hyperon Feels More Attractive Potential than N

Nuclear Caloric Curve

J. Pochadzalla et al., Phys. Rev. Lett. 75 (1995) 1040.
(GSI-ALLADIN collab.)



Boiling Temperature is Clearly Seen

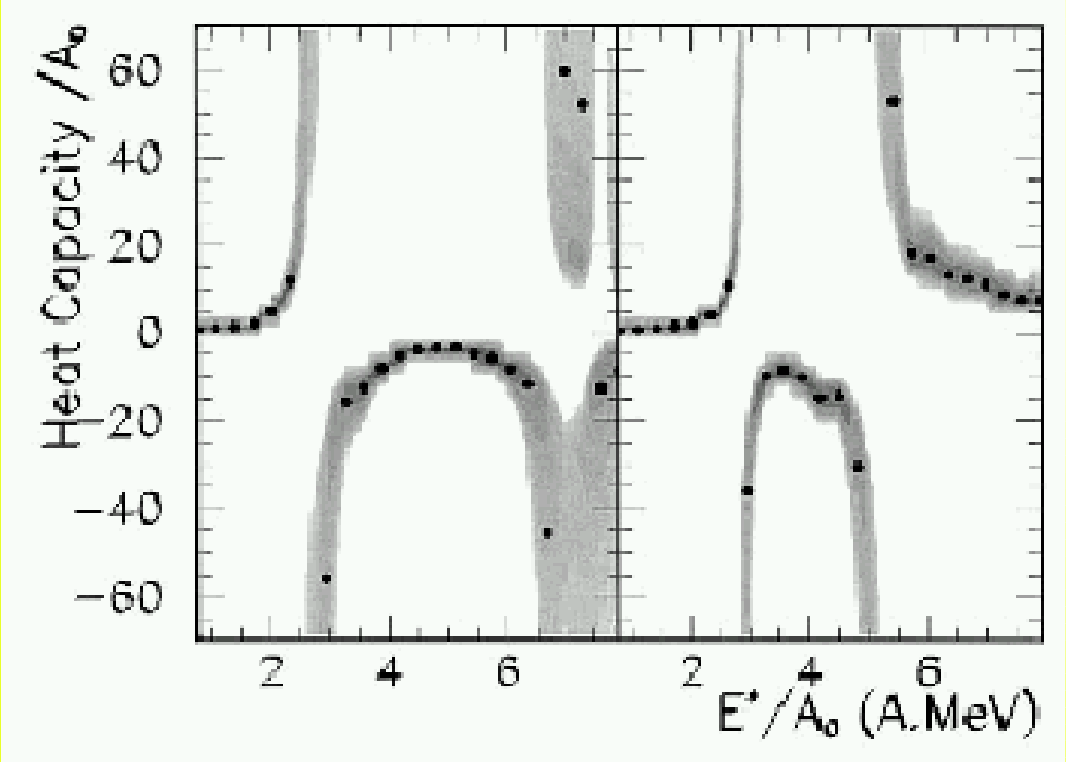
Fragment Yields are assumed
to follow Equilibrium Statistics

$$Y_f \propto g_f \exp\left((B_f + Z\mu_p + N\mu_n)/T\right)$$

$$\rightarrow \frac{Y(^4He)/Y(^3He)}{Y(^7Li)/Y(^6Li)} \propto \exp(\Delta B/T)$$

Negative Heat Capacity

M. D Agostino et al., PLB 473 (2000) 219.
(MSU Exp./INFN-IN2P3 Collab.)

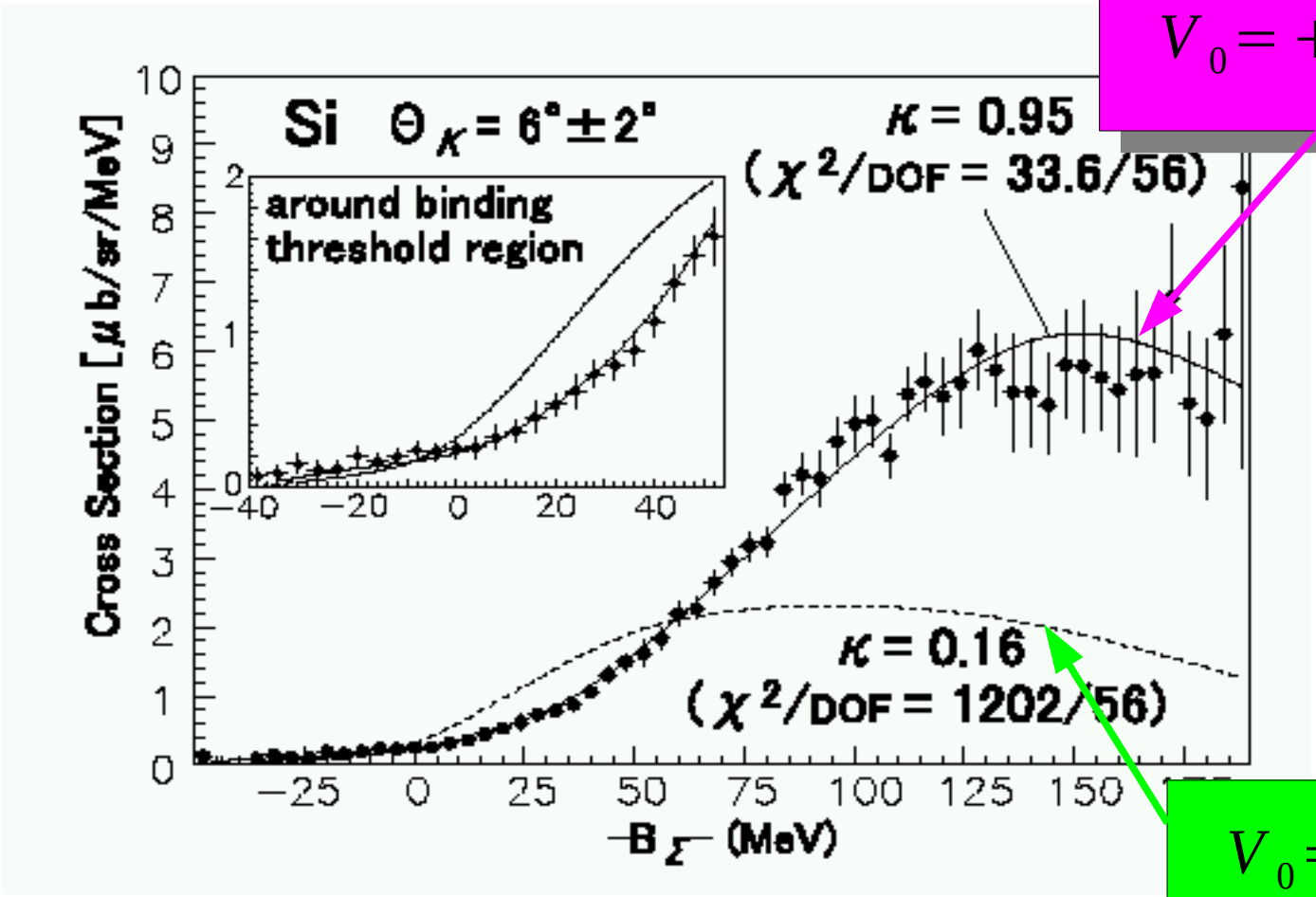


Negative Heat Capacity
➡ *First Order*

T and E^* are determined from ***Fragment Multiplicity*** and ***Kinetic Energy*** based on Theoretical Model

Does Σ Feel +150 MeV (Repulsive) in Nuclei ?

Noumi et al., Phys. Rev. Lett. 89 (2002) , 072301.



$V_0 = +150$ MeV

$V_0 = -10$ MeV

No Theoretical Model Support $V_0 = +150$ MeV *!*

➡ Big Puzzle !!

c.f. Kohno et al. (last JPS Meeting)

Strategy Meeting 2003.4.8-4.9

Akira Ohnishi

My Subject: Phen. Study of Hadronic Matter Dynamics

- Static and Dyn. Properties of Hadronic Matter under Various Conditions with Emphasis on Particle/Fragment DOF and Strangeness
- Phenomena: Particle/Fragment Spectra (Mass, Charge, Energy, Angle)
- Inputs: Cross Section, Mean Field, Fluctuation
- It is necessary to understand Reaction Mechanism as well.

Subjects

1. **High Energy Heavy Ion** (with Isse, Otuka, Sahu, Nara)
2. **Fragment Formation** (with Yamaguchi / Ishizuka, Sumiyoshi)
3. **Strangeness Nuclear Physics** (with Maekawa, Isshiki, Naito)

Current Study of Our Group

Heavy-Ion Collision at RHIC : Roles of Jets

(with Isse, Otuka, Sahu)

Non-Equilibrium Effects in IMF formation

(with Yamaguchi)

Hyperon Effects in Supernova Explosion

(with Ishizuka, Sumiyoshi, Yamada)

Hyperon Matter EOS

(with Naito)

Coherent Pions in Nuclei

(with Isshiki, Naito)

Sigma-Nucleus Potential

(with Maekawa)