



For the J-PARC Heavy-Ion Collisions

Masakiyo Kitazawa



Remarks!

- No solid results in this talk. Just delusional ideas.
- I am waiting for your opinions / discussions (throughout this meeting)!
- I welcome your criticisms.



What Physics are Suitable for J-PARC HIC?

Characteristics of J-PARC HIC

➤ High density



- QCD phase transitions
- Neutron stars / NS-NS merger

➤ High luminosity



- Various event selections
- Rare probes
- Event-by-event analyses



Take advantages of these properties!

$$\sqrt{s_{\text{NN}}} = 1 \sim 6 \text{ GeV}$$



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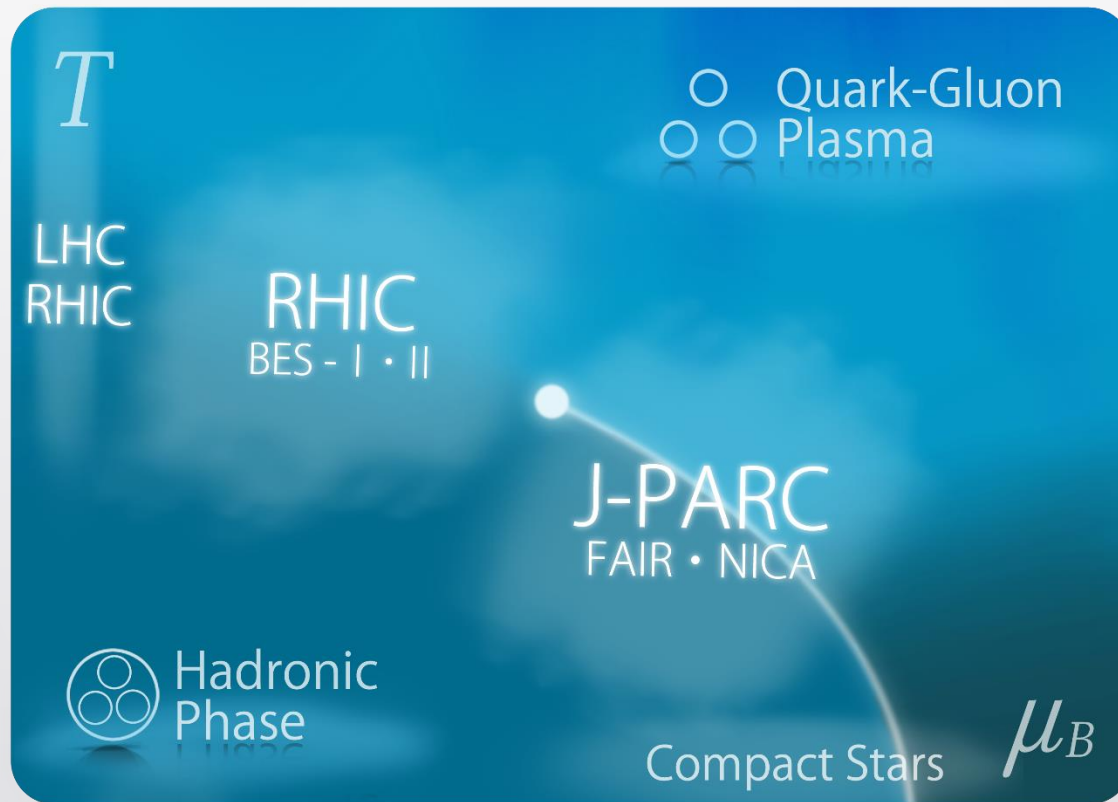
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High Density

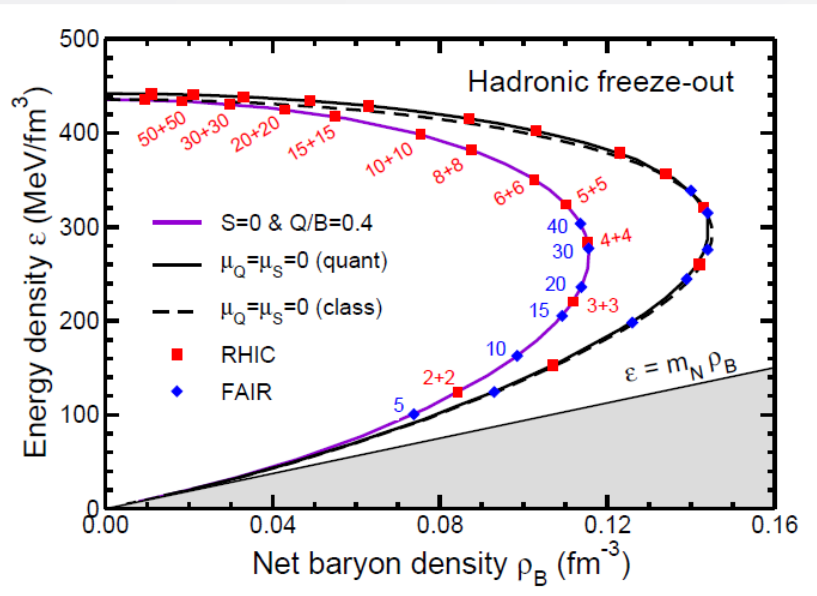


Special thanks to
C. Matsumura

Search of dense medium / QCD phase transitions

How Dense? : Freezeout

Chemical Freezeout



Randrup, Cleymans, 2006

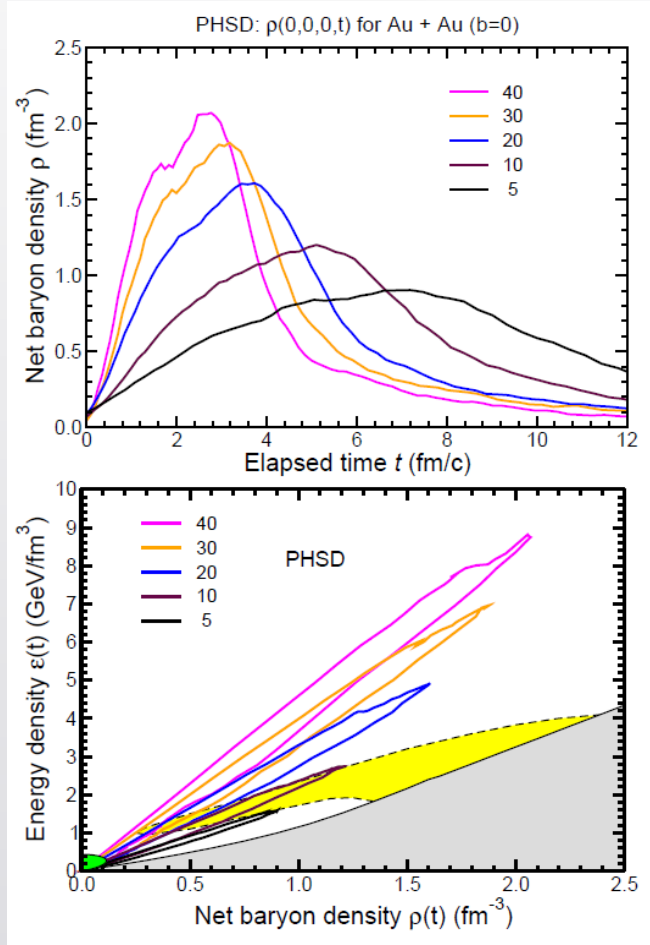
The most dense system at CFO with $\rho \sim 0.7 \rho_0$ is realized at

$$\left\{ \begin{array}{l} \sqrt{s_{NN}} \simeq 4 \text{ GeV} \\ E_{\text{lab.}} \simeq 30 \text{ GeV} \end{array} \right.$$

➔ It is in J-PARC energy

How Dense? : Highest

$\rho > 10\rho_0$ would be realized!



On the other hand,
JAM can reproduce dv_1/dy
and p_T spectra for J-PARC
energy.

Nara-san's talk, yesterday

Why?

I.C. Arsene+, PRC 75, 034902 (2007)



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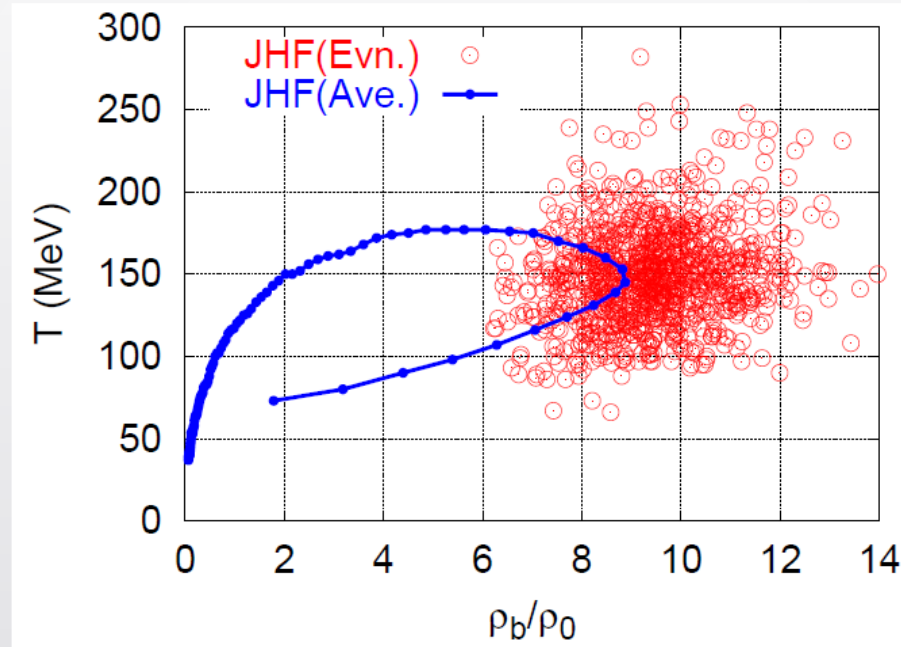
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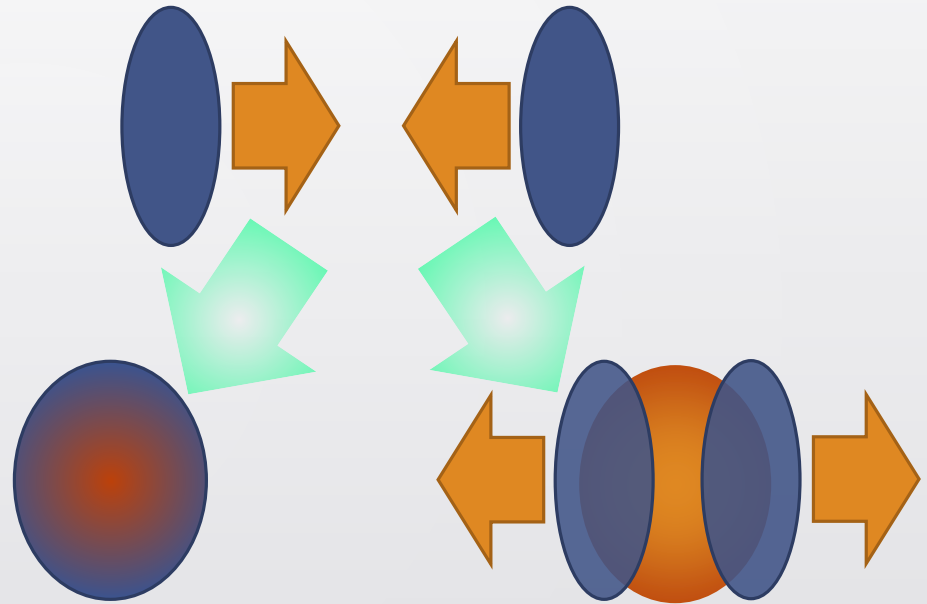
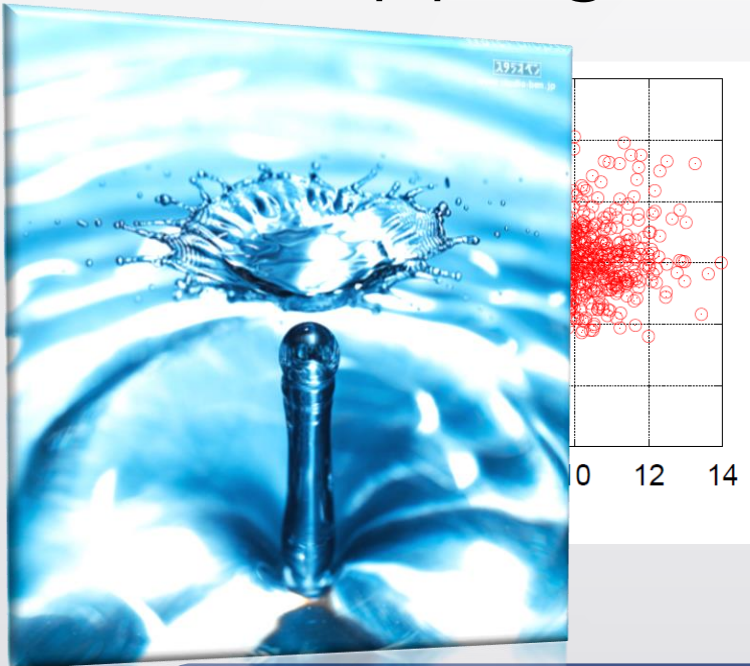
Large E-v-E Fluctuation?



Ohnishi, 2002

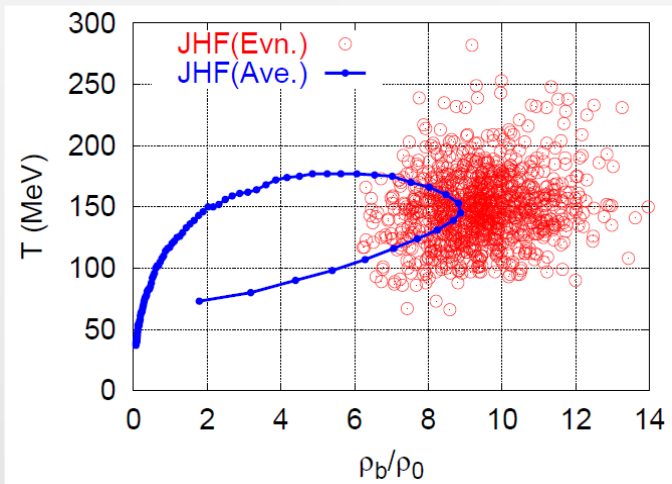
Baryon stopping seems to have strong **e-v-e fluctuation**.

Origin of e-v-e fluctuation 1:
Stopping \rightarrow Penetrate Transition



Structural Transition
stopping \rightarrow penetrate \rightarrow **Large fluctuation!**

Origin of e-v-e fluctuation 2:
Softening of EoS



Softening of the EoS

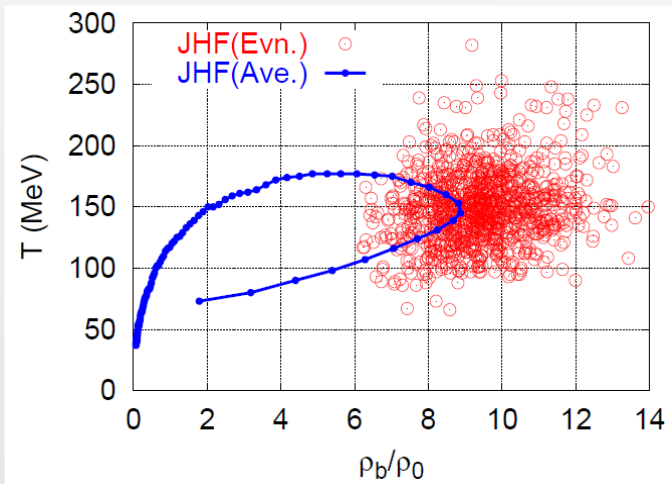


Enhanced susceptibility



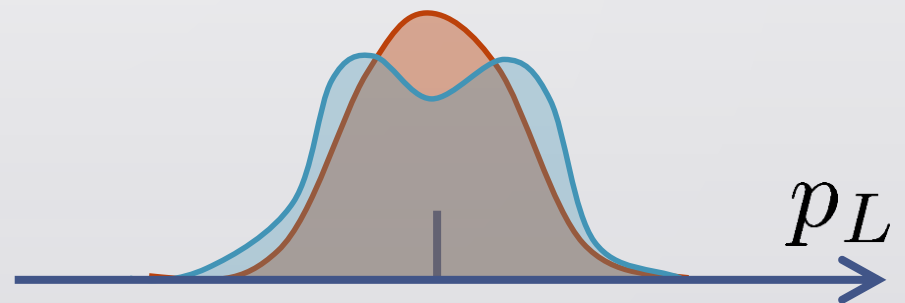
Large Fluctuation!

E-v-E Fluctuation of Density How to **Observe** Them?



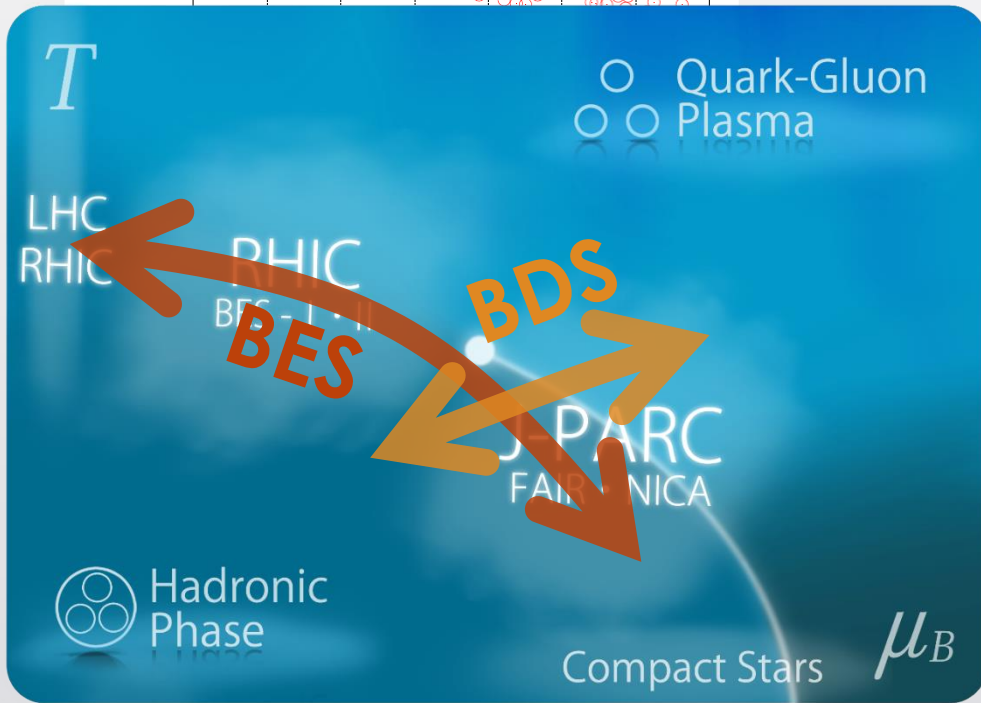
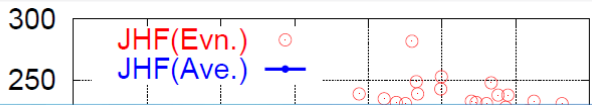
We need observables sensitive to baryon stopping

$$\text{Ex. } \langle p_L^2 \rangle$$



Or, strange number?
(by Nu Xu)

E-v-E Fluctuation of Density: How to **Use** Them?



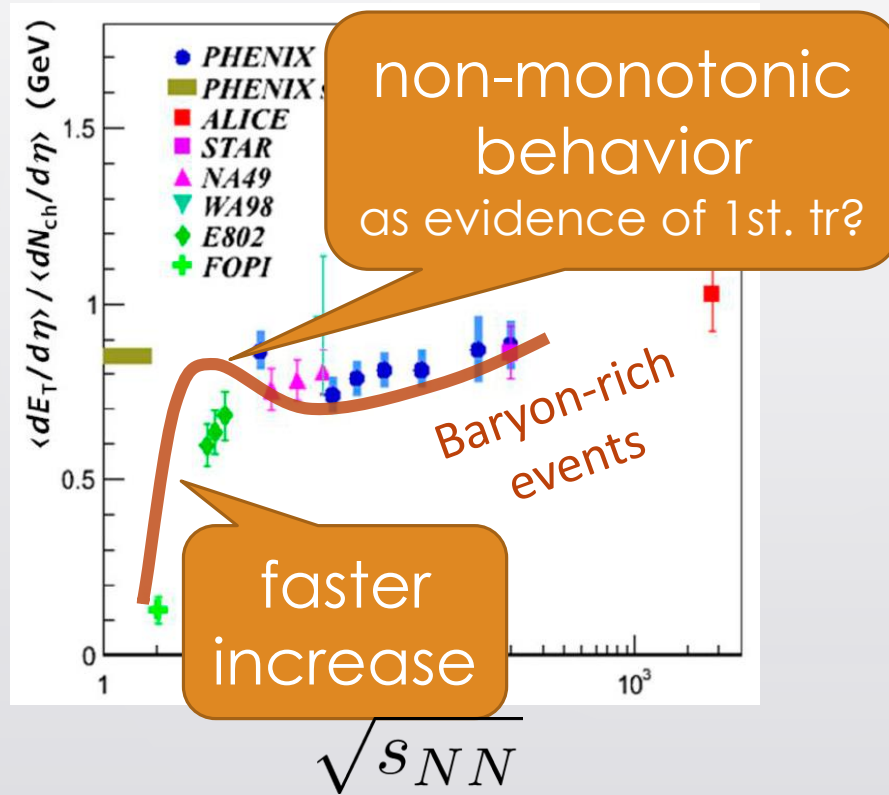
Event selection by
baryon stopping



**Baryon density Scan??
(BDS)**

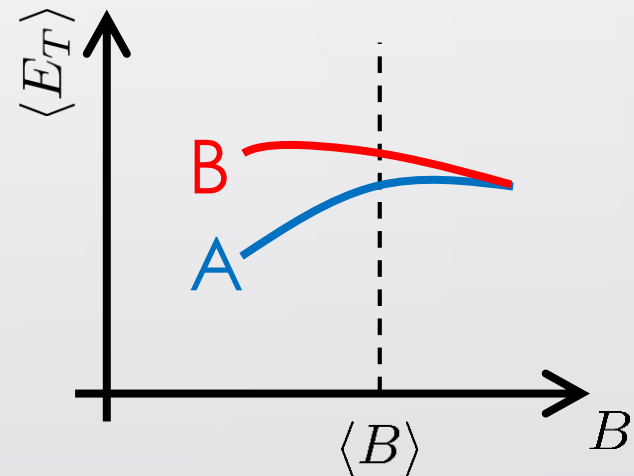
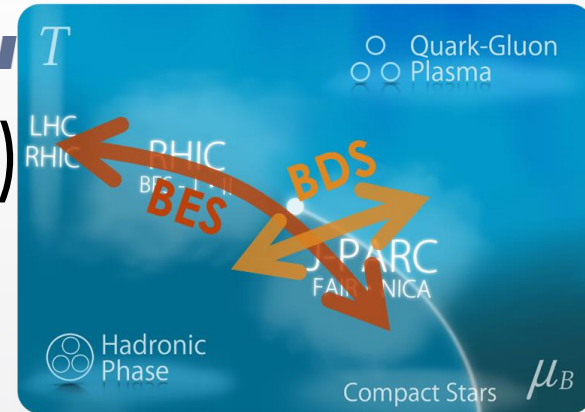
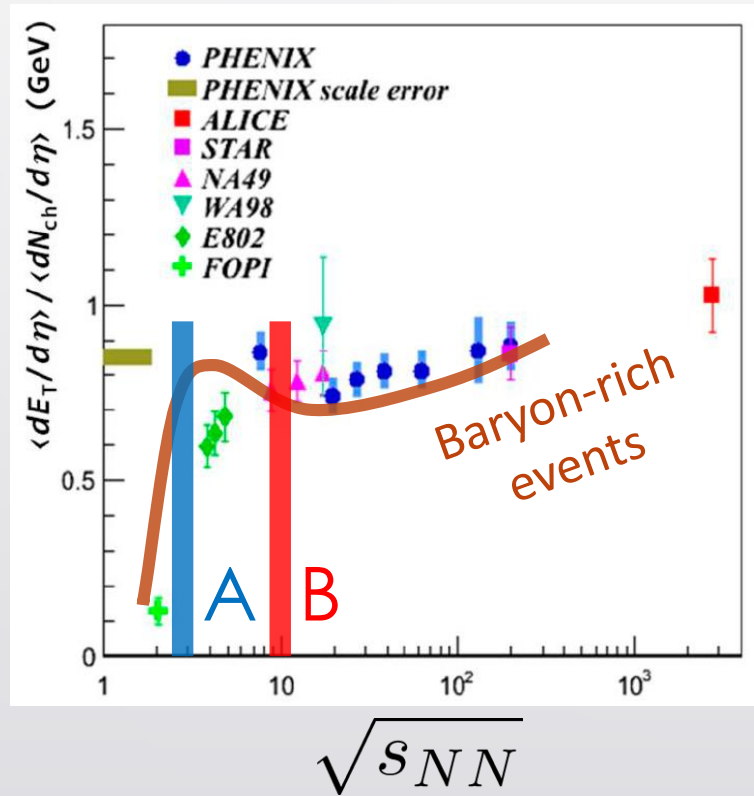
BDS (Baryon Density Scan)

average transverse energy



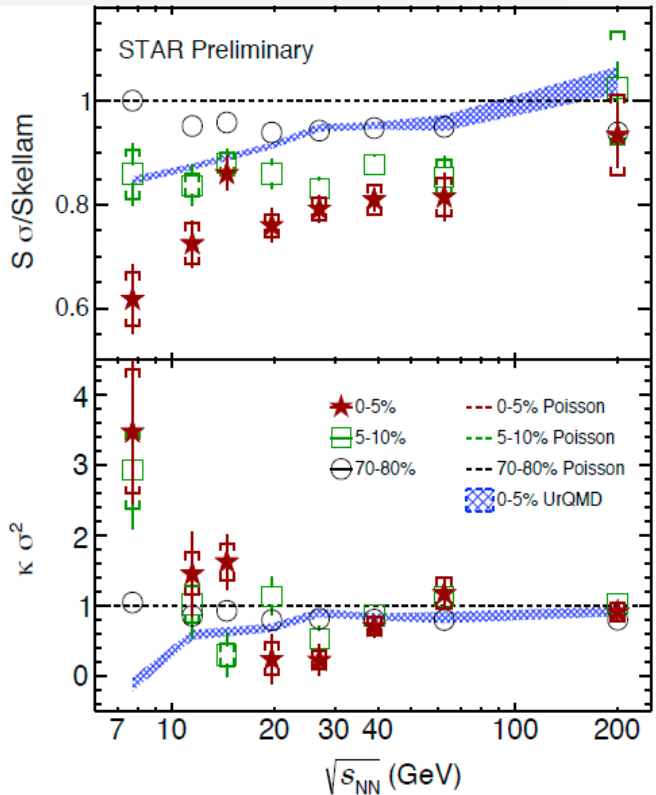
BDS (Baryon Density Scan)

average transverse energy



Softening of EoS by 1st transition

Event-by-event Fluctuations: Compared with high energy



STAR Collaboration, 2015

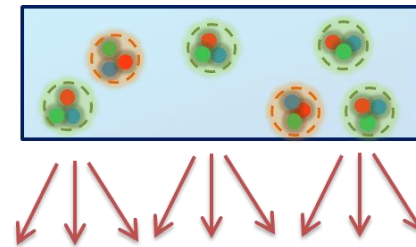
Thermal fluctuations
are concerned @ high \sqrt{s} .



Measurement of thermal fluc.
justified only under **Bjorken picture**

Asakawa, MK, arXiv:1512.05038

Pictorial
view for
low \sqrt{s}



detector



Other Ideas

- Event-by-event dv_1/dy , radial flow, ...
- Correlation b/w baryon stopping and
 - v_1 , strangeness, dE_T/dy , ...



What Physics are Suitable for J-PARC HIC?

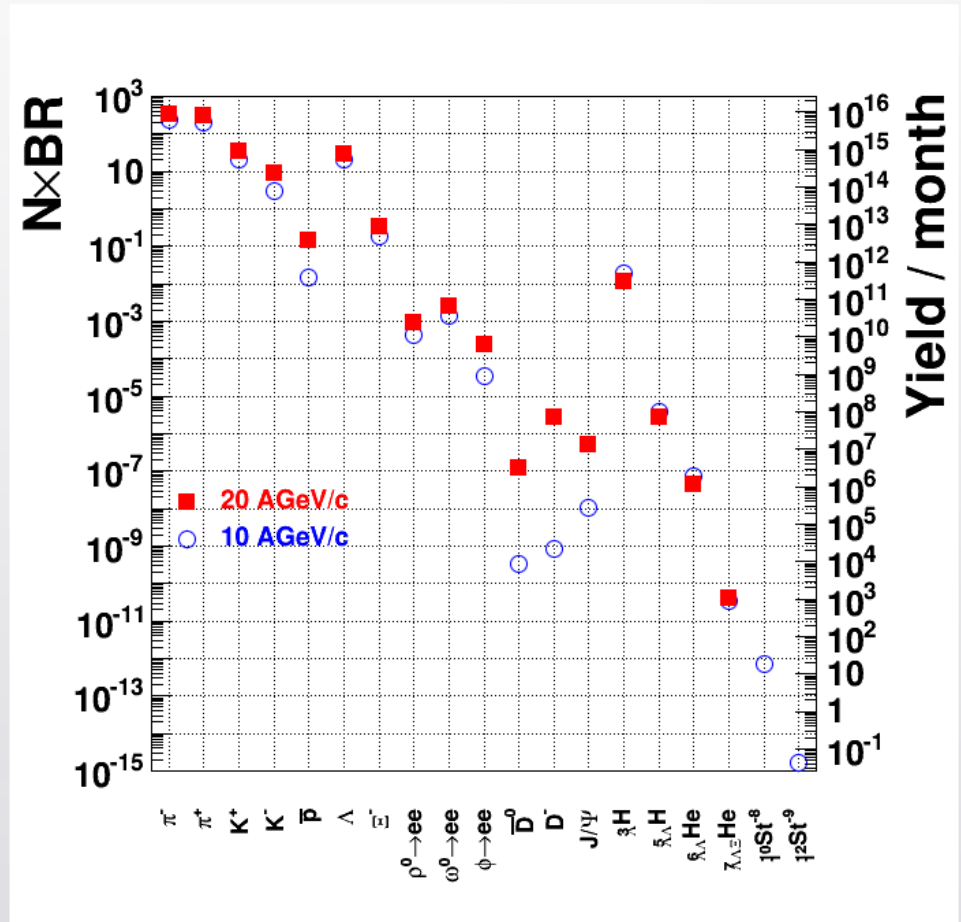
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 - ➔ • Various event selections
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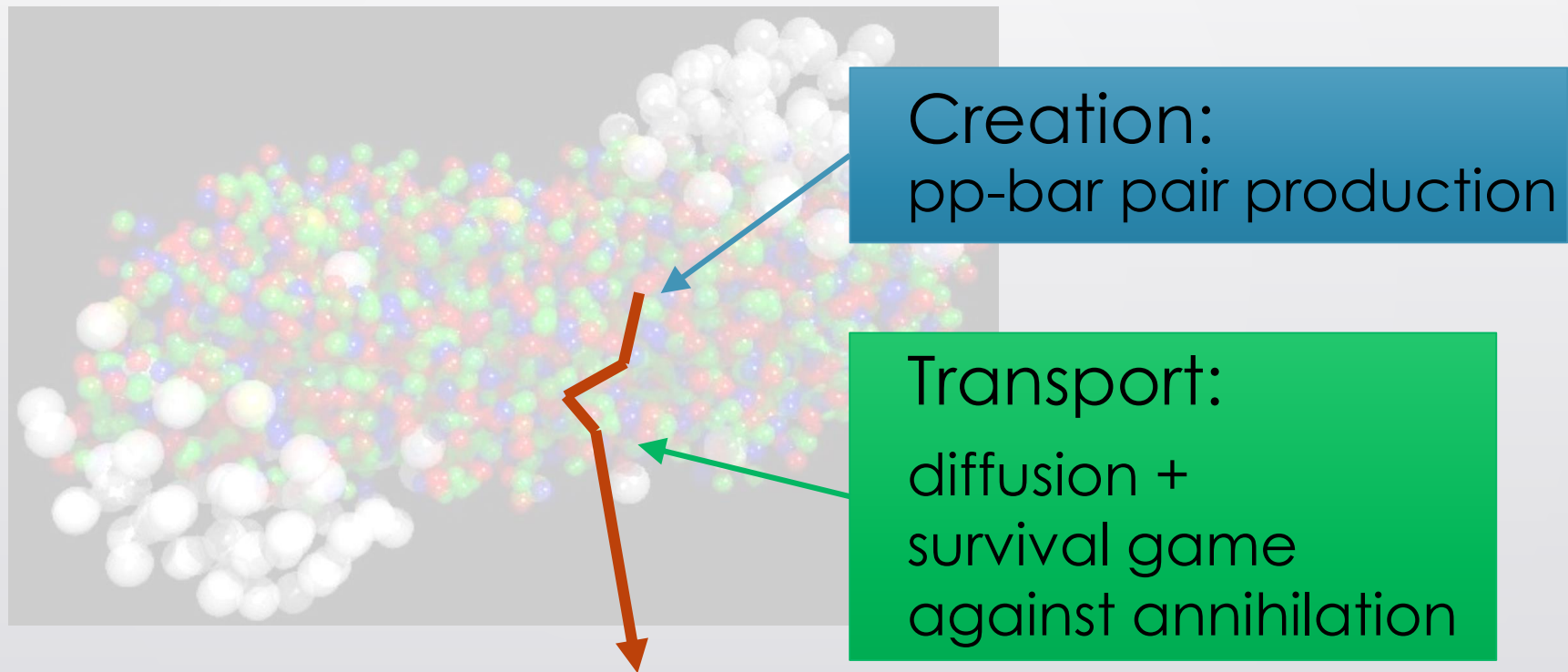
$$\sqrt{s_{\text{NN}}} = 1 \sim 6 \text{ GeV}$$

Rare Probes

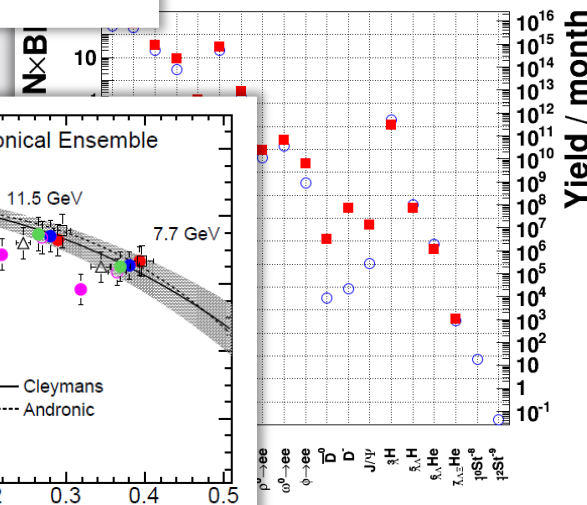
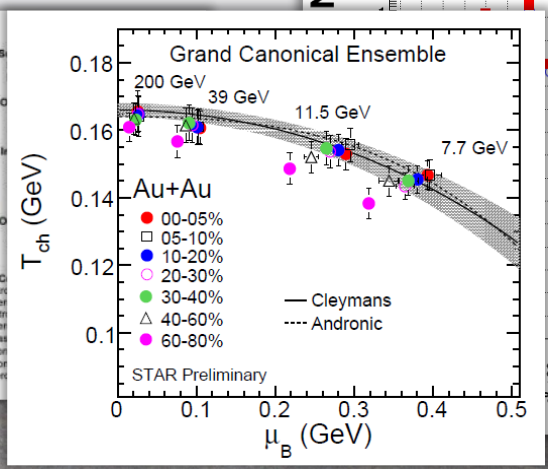
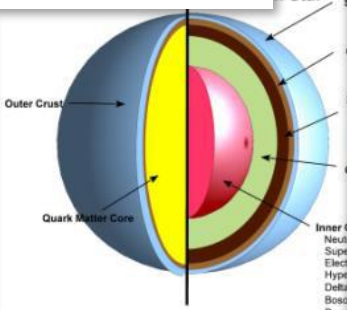
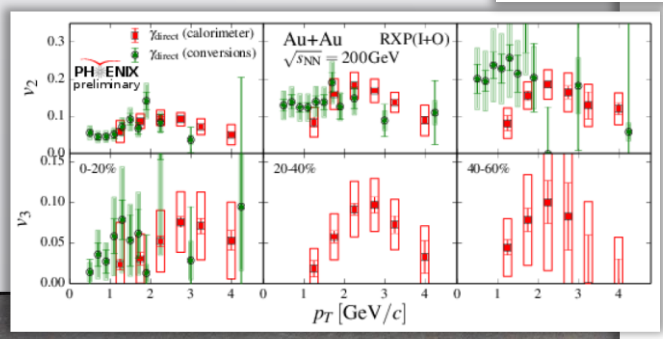
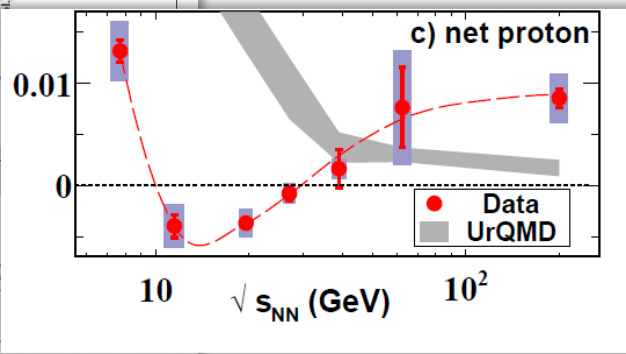
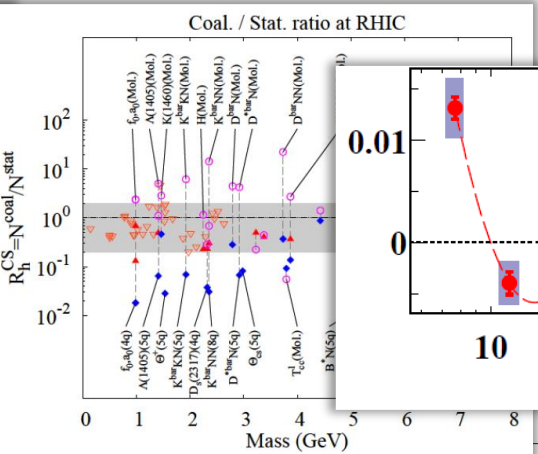
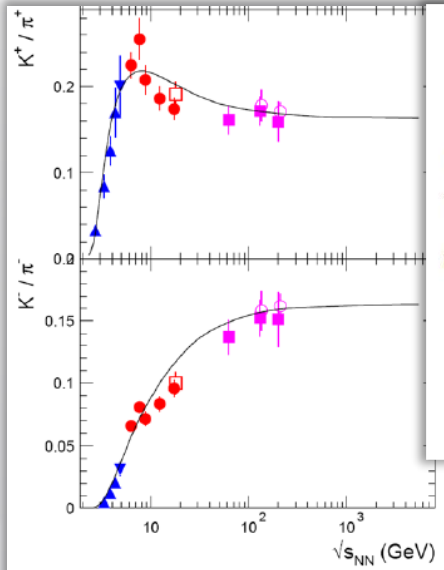
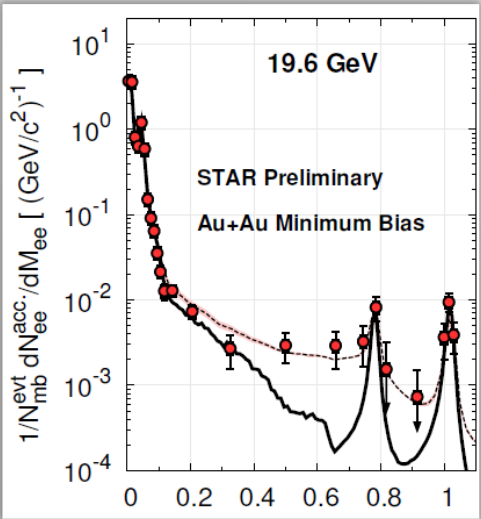
- Exotic hadrons
- Strangelet
- **Strangeness**
- **Anti-protons**



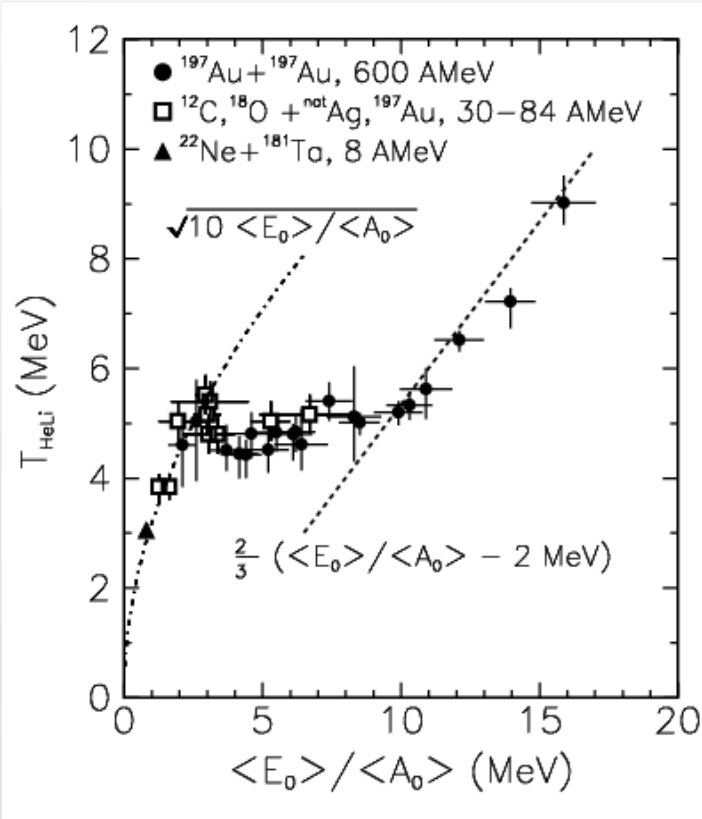
Stochastic Description for
anti-p and s transports?



And, of course, Other Many Important Topics



Liquid-Gas Phase Transition of Nuclear Medium



Any possibility to perform a similar analysis in HIC...?



Summary

Characteristics of J-PARC HIC
High density / High luminosity

We should be able to have more ideas to take
these advantages of low-energy collisions!

event selections / e-b-e analyses / rare probes

Important to accelerate J-PARC/FAIR/NICA programs!

$$\sqrt{s_{\text{NN}}} = 1 \sim 6 \text{ GeV}$$