Vector meson measurement at JHF

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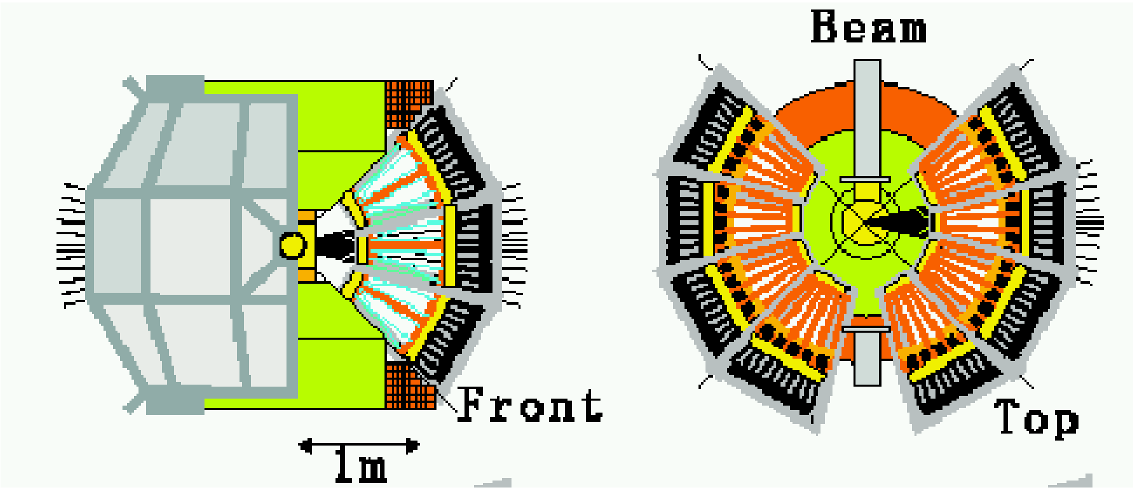

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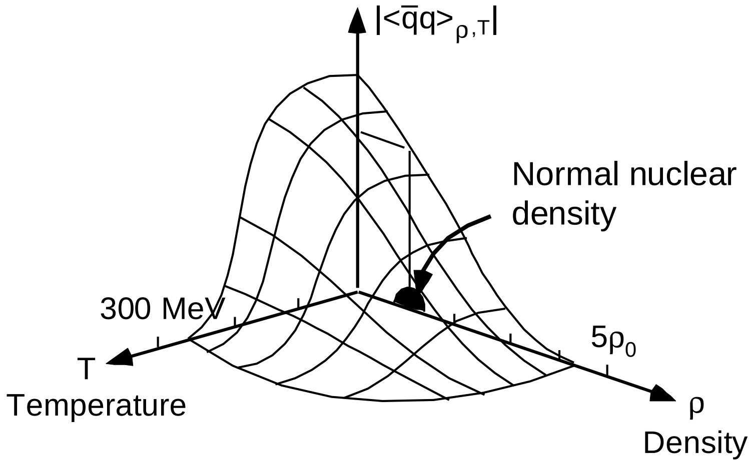
- Low mass lepton pair measurement: CERES, KEK-PS E325 etc.
- At JHF
  - Yield
  - Secondary beam
  - Spectrometer

Chiral symmetry restoration

- hadron mass in real world :
  constituent quark mass (~350MeV) ~
  spontaneous braking of chiral symmetry
- quark condensate $\langle \bar{q}q \rangle$ as an order parameter of the chiral symmetry

$$\Downarrow$$

- In hot/dense matter,
  - the (partial) chiral symmetry restoration
  - $\langle \bar{q}q \rangle$ decreasing
  - hadron modification is expected



In dense matter

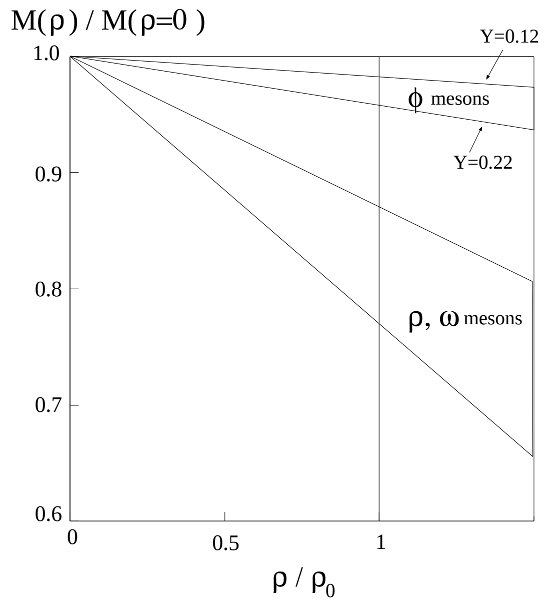
$$\frac{\langle \bar{q}q \rangle_\rho}{\langle \bar{q}q \rangle_0} = 1 - (0.34 \pm 0.05)\frac{\rho}{\rho_0}$$

(Drukarev *et al.*, 1991)

Vector meson modification in dence matter

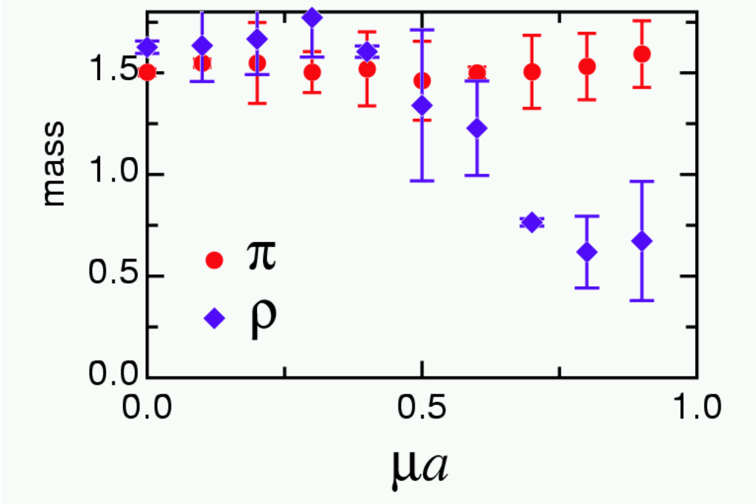
For example,

- Hatsuda and Lee, 1992, QCD sum rule
  (PRC46(1992)R24)
  vector meson (ϕ, ρ and ω)mass shift in dense matter



- Muroya, Nakamura and Nonaka, 2002, Lattice
  (hep-lat/0208006)

  mass decreasing in vector channel, in finite chemical potential

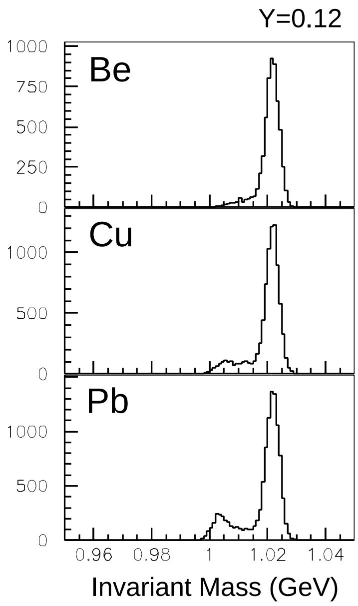


Experiments

invariant mass spectra for ϕ

decaying at finite density in nuclei ($0< \rho/\rho_0 <1$)

- second peak made by ϕ's which decay in nuclei (no width-changing case)



(simulation)

experimental study

- reported vector meson modification

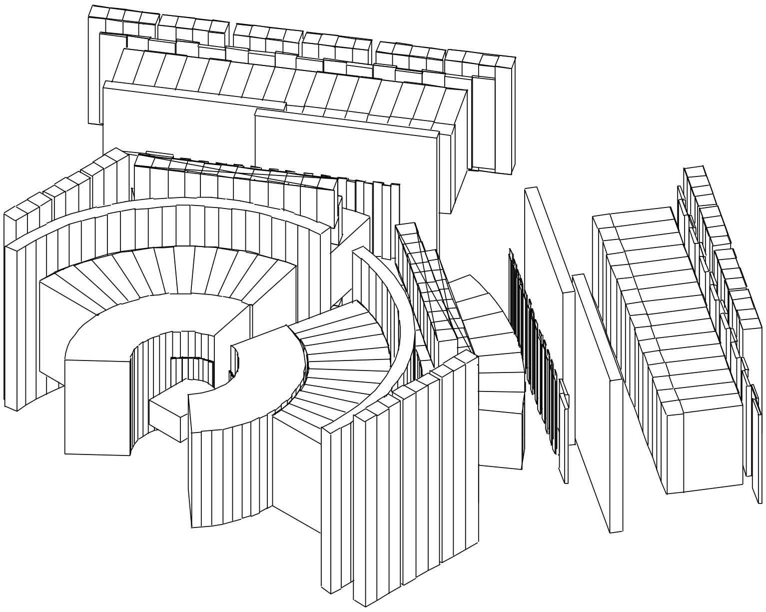
CERES(CERN SPS) $\rho/\omega \to ee$
KEK-PS E325 $\rho/\omega \to ee$
TAGX(INS) $\rho \to \pi\pi$

Experimental result from KEK-PS E325

data taking 1997-2002

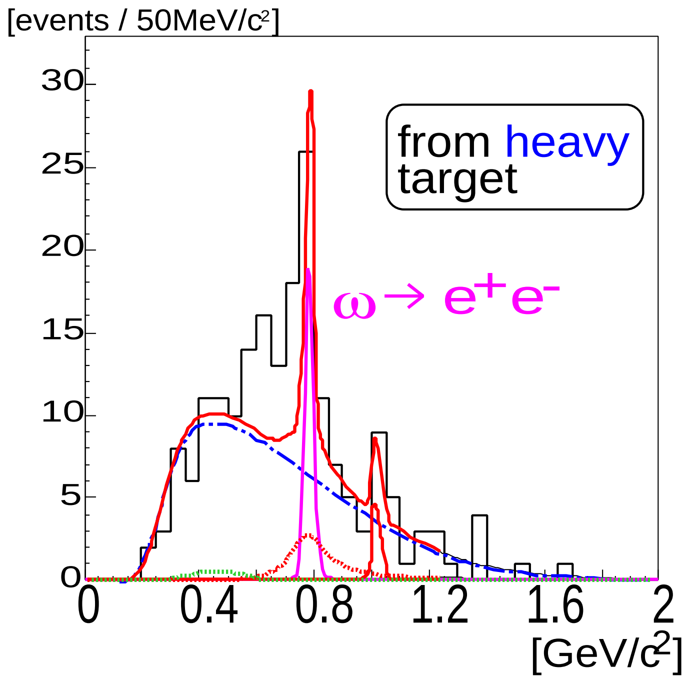
experimental setup

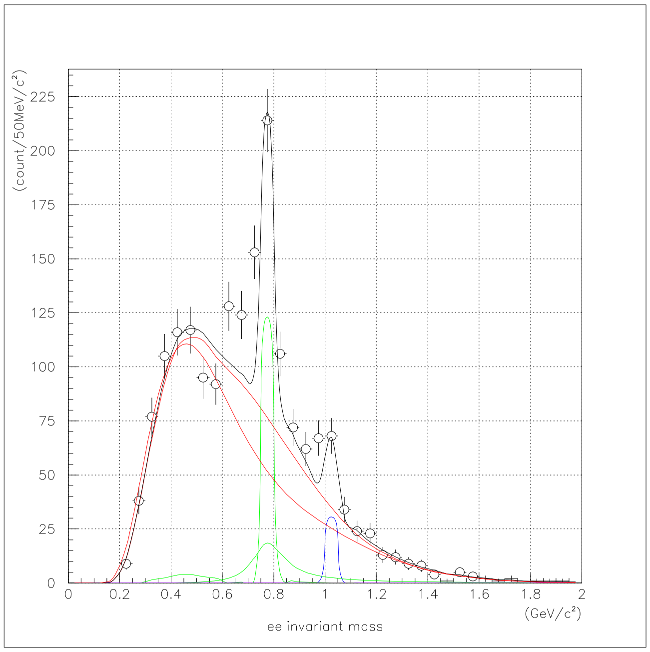
C/Cu target ($\sim$0.1% interaction)
12GeV p beam ($\sim 10^9$/spill)



data from E325 p+Cu (1998/99)

(PRL86(2001)5019, etc)





S.Yokkaichi, NP02 at Kyoto

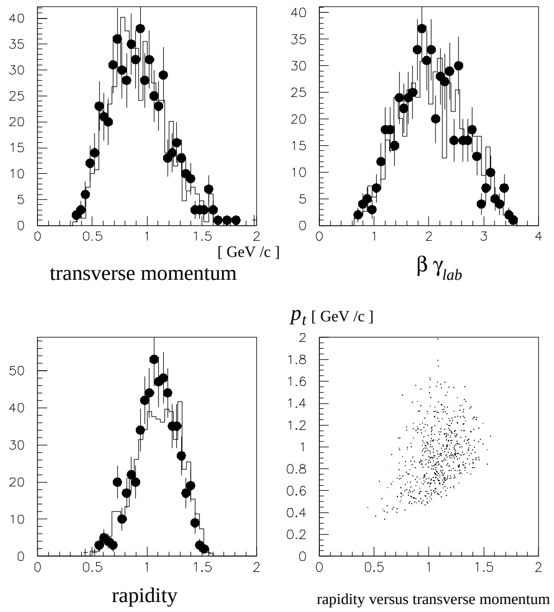
Toward the experiment at JHF to measure vector mesons

- Status
  - vector meson modification seems established by various experiments including E325.
  - high statistics and good resolution is still needed to see modified ϕ and analyze with kinematic variables.
    e.g. slow particles have larger possibility of decay under the effect.
- Experiment at JHF:
  - target: measurement of $\phi \to e^+e^-$
    - good S/N and good resolution
    - see the 'shifted' component in many momentum binning
    - ρ/ω also can be measured at same time
    - possibility of $\phi \to K^+K^-$, $K^* \to K\gamma$?
    - possibility of Heavy Ion collision ?
  - use high intensity beam and thin target
    primary proton beam / high momentum secondary beam
- today,
  - detector design (talk given by K.Ozawa)
  - yield estimation using the simulation code JAM

Yield estimation using the simulation code JAM

JAM

- good agreement at 12GeV p+A
  (kinematical distribution & absolute cross section) measured by E325
  (related talk given by T.Tabaru at PANIC02)



- good agreement with the scaling law for vector meson production
  $\frac{m^3}{\Gamma}\sigma(\tau) \propto \frac{1}{\sqrt{\tau}}(1-\tau)^{10}$, $\tau = m^2/s$

  in 12GeV and 50GeV (ratio = ~6)

50GeV p + Cu $\to \phi$ + X

23% accepted for :

forward : azimuthal 12°,

backward: 132°,

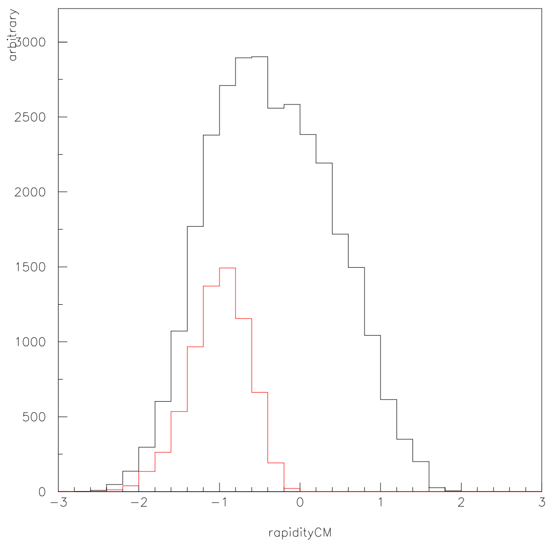
vertical: ±45°

E325 magnet (0.78Tm),

0.2 < p_e < 2.5GeV/c

rapidity distribution of ϕ

generated by JAM



ϕ yield estimation

total ϕ production CS for Cu target

primary proton (scaled at 12GeV E325 data)		acceptance
12GeV p	1.0mb	45%
30GeV p	3.0mb	31%
50GeV p	5.1mb	23%
secondary (not scaled)		
3GeV/c K^-	1.2mb	50%
6GeV/c K^-	10mb	50%
12GeV/c K^-	20mb	26%
12GeV/c π^-	3.6mb	-
20GeV/c K^-	26mb	-
20GeV/c π^-	6.7mb	-

yield of ϕ meson

5mb (50GeV proton)
0.1% interaction Cu target
1×10^9 proton /3.5sec
Acceptance 20%
ee branch 3×10^{-4}

~9000 of $\phi \to e^+e^-$ /24hours. w/o trigger eff., analysis eff., DAQ dead time etc.
(actually only 12 times larger than E325)

Secondary beam intensity

production target parameter(given by K. H. Tanaka)

2% interaction / production angle 5° / 0.2msr% / 120m length

intensity

for 30GeV, $\sim 1\times 10^{14}$ primary proton /spill, using Sanford-Wang

	number at production	decay (120m)
4.7°		
3GeV/c K^-	1.2M/spill	5%
6GeV/c K^-	1.1M/spill	7%
12GeV/c K^-	0.07M/spill	26%
12GeV/c π^-	1.2M/spill	84%
0°		
12GeV/c K^-	1.7M/spill	26%
12GeV/c π^-	29M/spill	84%

for 50GeV, $\sim 3.3\times 10^{14}$ primary proton /spill, cannot use Sanford-Wang:
...up to factor 10 of the 30GeV case?

Summary

Vector meson measurement at JHF

- explore the chiral symmetry restoration at normal nuclear density
- higher statistics to analyze momentum dependence etc. of spectrum
- use primary beam for high statistics
- measure $\phi \to e^+e^-$ (and $\rho/\omega \to e^+e^-$)
- ϕ meson yield :
  simply scaling, 12 times of E325

to be discussed

- $\phi \to K^+K^-$, $K^* \to K\gamma$
- trigger/background study
- possibility of using 10^{10} beam : means 10^7 interaction/spill
- availability for Heavy ion collision : to explore high density state($\rho = 5 \sim 10\rho_0$?)