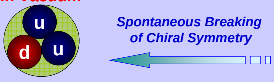
Measurement for e^+e^- Spectral Modification of ρ/ω mesons in 12GeV p+A reactions

M. Naruki(RIKEN) for the KEK-PS E325 collaboration

nucl-ex/0504016

introduction

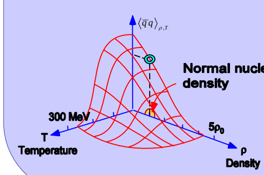
Physics Motivation



Hadrons ~1GeV/c^2

Constituent quarks ~300MeV/c^2

Current quarks ~5MeV/c^2



How to detect?

Vector meson mass at normal nuclear density

Vector Mesons

ρ, ω

Large mass modification ~150MeV/c2 at $\rho = \rho_0$

Large cross section spectrum

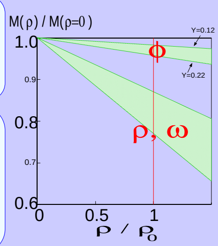
φ

Mass modification 20 ~ 40MeV/c^2 : relatively small

Small decay width (4.4MeV/c^2), no other resonance nearby : sensitive to small mass modification

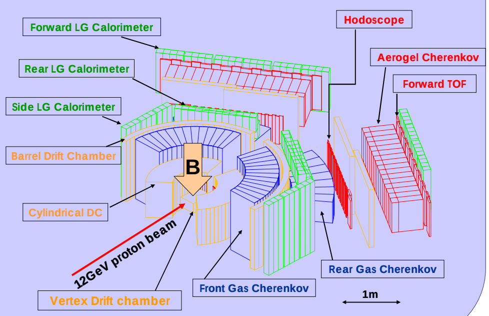
predictions of vector meson modification in medium

Brown, Rho(1991), Hatsuda, Lee(1992), Klingl, Kaiser, Weise(1997), etc.



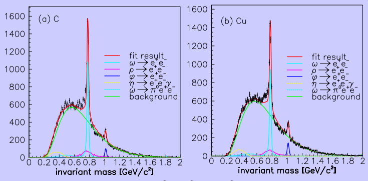
Hatsuda & Lee PRC 46, R34(1992)

Detector Setup



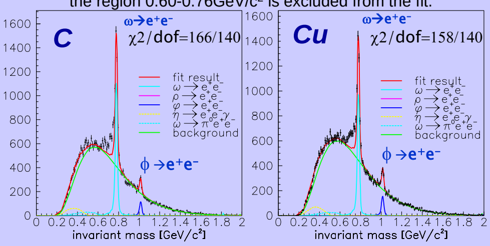
Results

At first, the fit was done for the all mass region, but the fit could not reproduce our data. The fitting χ^2/dof was 371/162 and 316/162 for the carbon and copper target, respectively. Then we made the fit for the data excluding the low-mass side of omega →



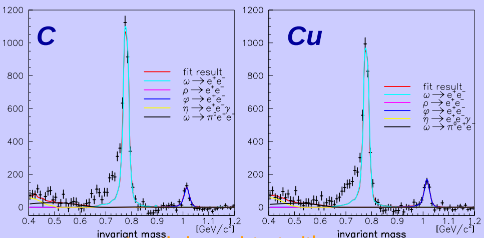
Invariant Mass Spectrum of e^+e^-

the region 0.60-0.76GeV/c^2 is excluded from the fit.



the excess over the known hadronic sources on the low mass side of ω peak has been observed.

after background subtracted



ρ/ω ratio is consistent with zero

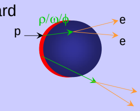
Nρ/Nω=0.0±0.02(stat.)±0.2(sys.)   0.0±0.04(stat.)±0.3(sys.)

It is pretty much surprising because the ρ/ω is known to be unity in pp reactions

Model Calcluation

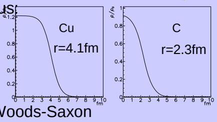
Model

- generated at surface of forward hemisphere of target nucleus
  - α_ω=0.68±0.04 (α_ϕ=0.93±0.15)



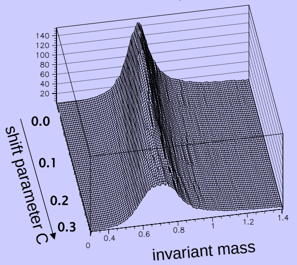
  - decay inside nucleus

	C	Cu
ρ	52%	66%
ω	5%	10%

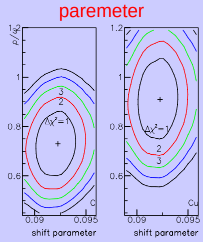


- density distribution - Woods-Saxon
- mass spectrum: relativistic Breit-Wigner Shape
- pole mass: $\frac{m^*}{m} = 1 - C\frac{\rho}{\rho^0}$ (Hatsuda-Lee formula)
- no width modification

Shift Parameter C VS ρ spectrum

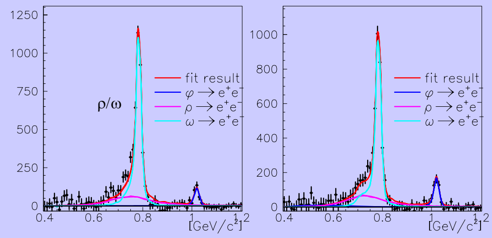


Confidence ellipsols for shift paremeter



- We fit the data to determine the shift parameter C
- C/Cu data are fitted simultaneously
- fit parameters:
  - shift parameter C
  - relative abundances of φ, ω and background
  - ρ/ω ratio

fit result



- production ratio ρ/ω VS shift parameter C
- Best-Fit value is

C= 0.092±0.002

ρ/ω = 0.73±0.12 (C)

0.91±0.17 (Cu)

the tendency of the excess for C and Cu are well reproduced by the model including the mass modification.

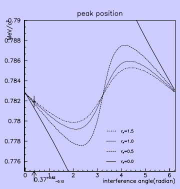
→ mass of ρ/ω meson decrease 9% at normal nuclear density.

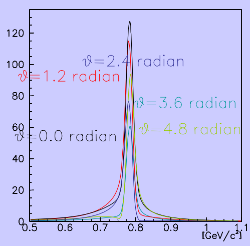
ρ–ω interference

ρ–ω interfering resonance shape:

$$F^2 = |F_\rho + RF_\omega|^2,\ F_V = \frac{1}{m^2 - m_V{}^2 + im\Gamma_V}$$

$$R = \frac{\langle ee|\omega\rangle\langle\omega|pA\rangle}{\langle ee|\rho\rangle\langle\rho|pA\rangle} = \sqrt{\frac{m_\omega\Gamma_{\omega\to ee}}{m_\rho\Gamma_{\rho\to ee}}}\sqrt{\frac{\sigma_\omega}{\sigma_\rho}}e^{i\theta}$$





•data was fitted with the interfering ρ–ω shape for various $\sigma_\rho/\sigma_\omega$ and angle

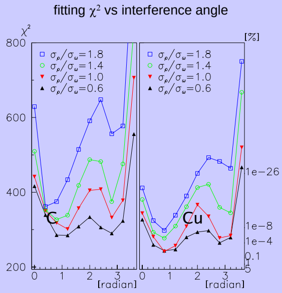
•best case

✓$\sigma_\rho/\sigma_\omega$=0.6,θ=0.8rad

✓χ2=285/163(C) ,242/163(Cu)

✓probability<1x10⁻⁴

fitting χ^2 vs interference angle



no solution to reproduce the excess

Conclusion

- KEK PS-E325 experiment measured e^+e^- pairs in 12GeV p+A reactions to investigate invariant mass of vector mesons decaying in nuclear matter.
- We have observed the excess over the known hadronic sources at low-mass side of ω. Obtained ρ / ω ratio indicates that the excess is mainly due to the modification of ρ mesons.
- ρ–ω interference did not explain our data.
- Model calculation based on the mass modification reproduced the tendency of the data. The fit result shows that the mass of ρ/ω decreases by 9% at the normal nuclear density.