

Experimental Signature of in-medium mass modification of vector mesons at normal nuclear density

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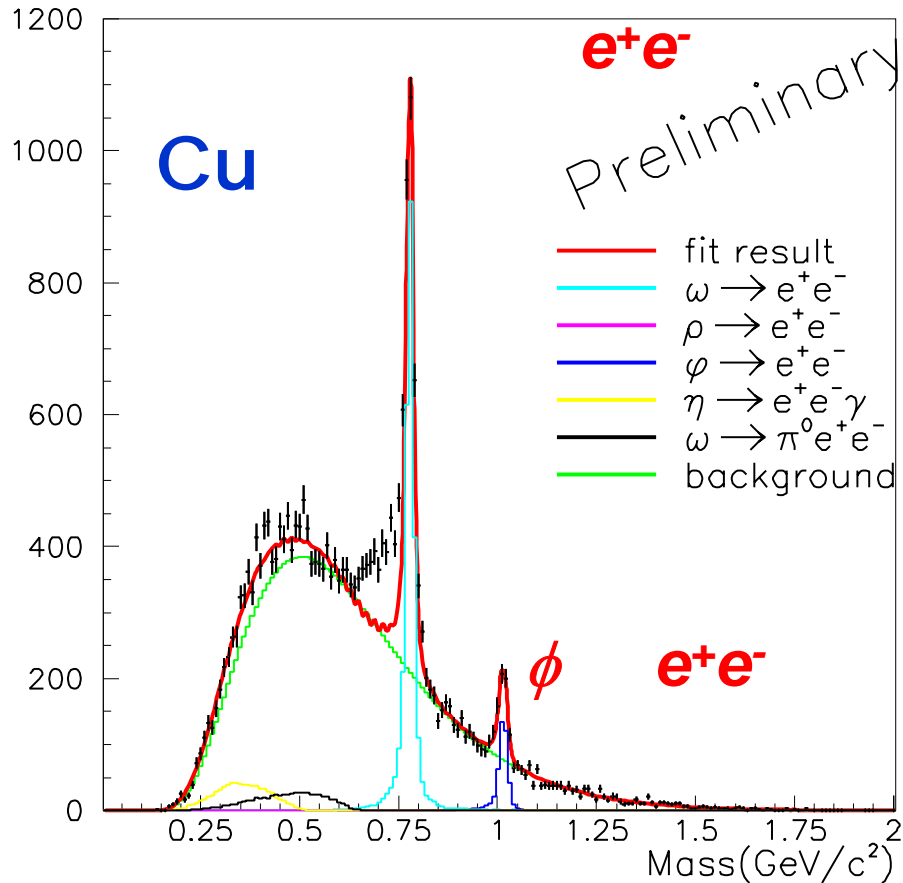
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(KEK-PS *E325* Collaboration)

Abstract (KEK-PS E325)

We have measured e^+e^- and K^+K^- invariant mass spectra to investigate in-medium mass modification of vector mesons in $12\text{GeV } p+A \rightarrow \rho, \omega, \phi + X$ reactions.

e^+e^- invariant mass



-Contents-

- Physics Motivation
- Experimental Setup
- Preliminary Result of 2002 data analysis

Physics Motivation

Effective Mass of Quarks

In Vacuum

$$m_u \cong m_d \cong 300 \text{ MeV}$$

$$m_s \cong 500 \text{ MeV}$$

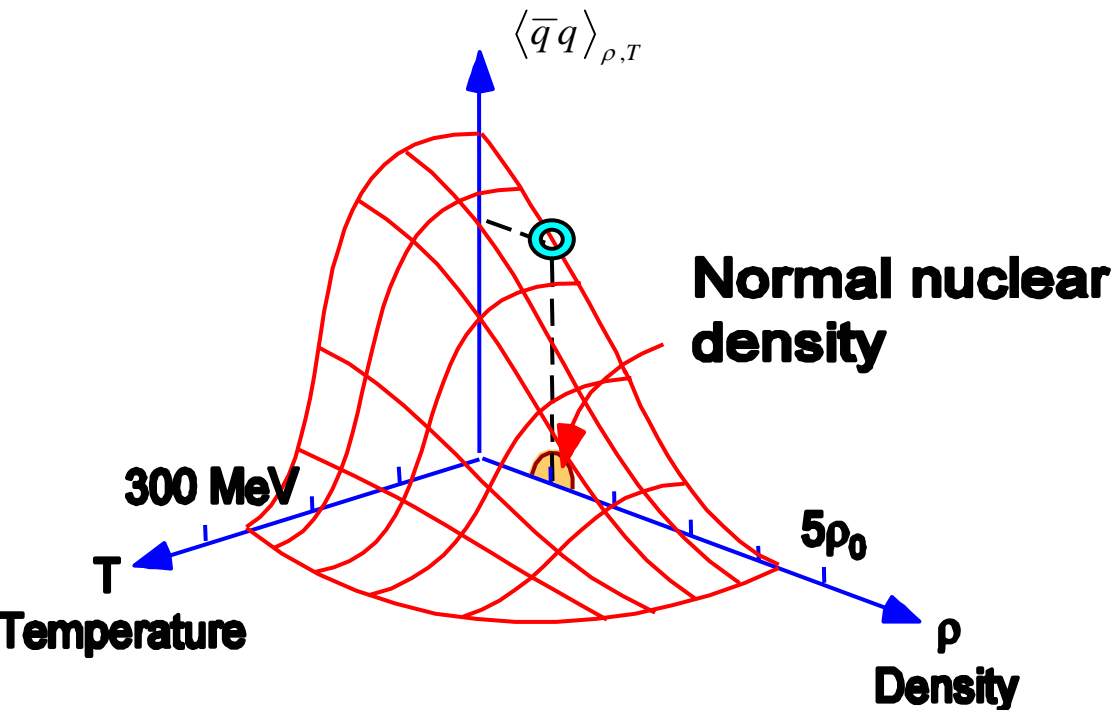


*Spontaneous Breaking
of Chiral Symmetry*

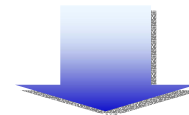
At High ρ / T

$$m_u \cong m_d \cong 5 \text{ MeV}$$

$$m_s \cong 150 \text{ MeV}$$



How to measure ?



Using Vector Mesons

Vector Meson

Mass of Vector Meson ρ, ω, ϕ
= $2 \times M_q$ + small interaction term

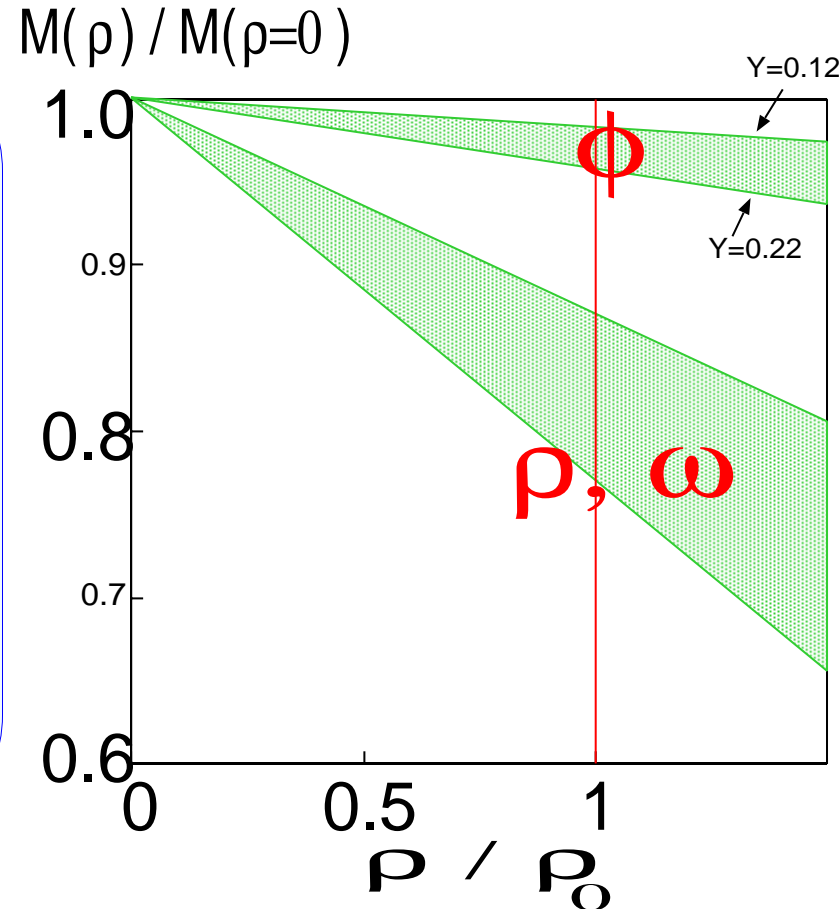
Hatsuda & Lee P.R.C 1992

ρ, ω

- large mass modification
 150MeV at $\rho = \rho_0$
- large cross section

ϕ

- mass modification $20 \sim 40\text{MeV}$
- small decay width ($4.4\text{MeV}/c^2$)
sensitive to mass modification



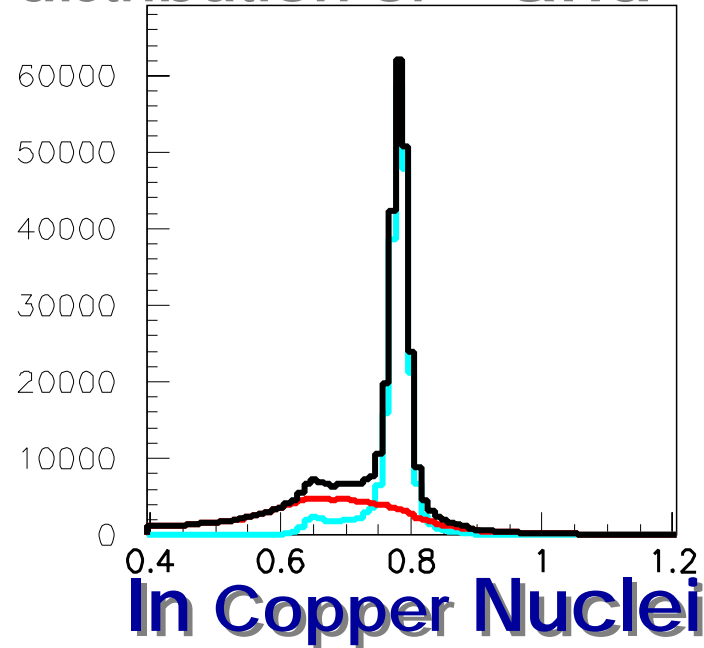
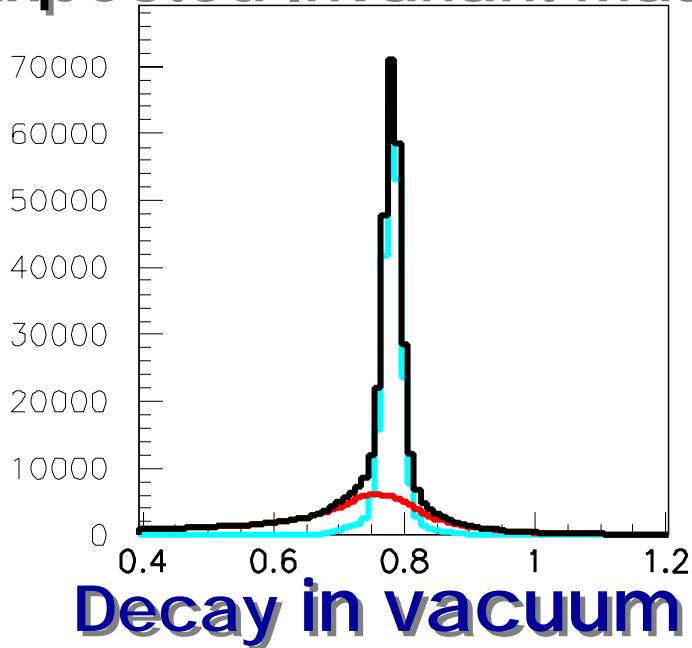
Expected Signal

In 12GeV $p + A$ $\rho, \omega, \phi + X$
Invariant Mass of e^+e^- , K^+K^-

mass modified by the formula
 $m^*/m = 1 - 0.16\rho/\rho_0$

Prog.Theor.Phys.95(1996)1009

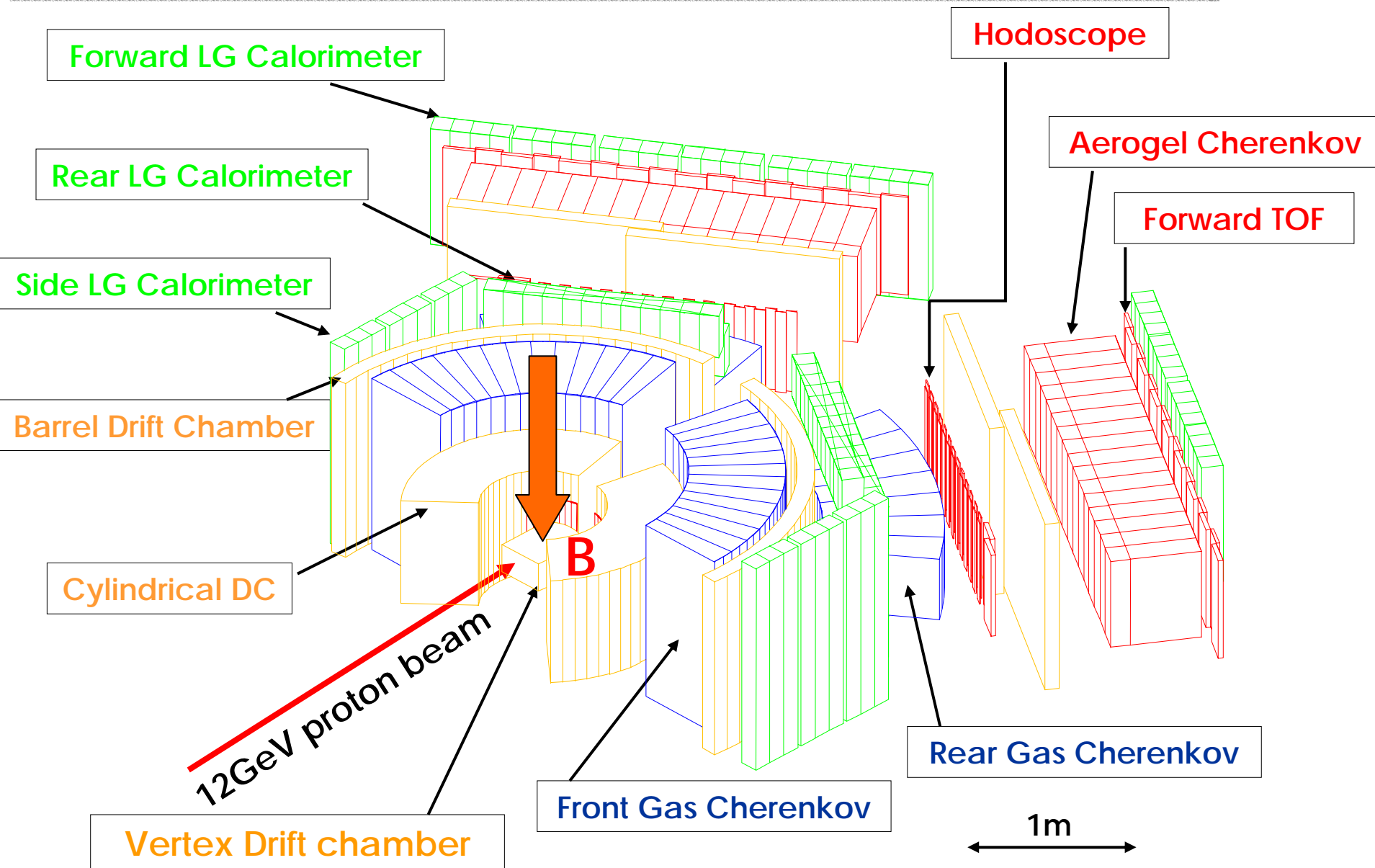
Expected Invariant Mass distribution of ρ and ω

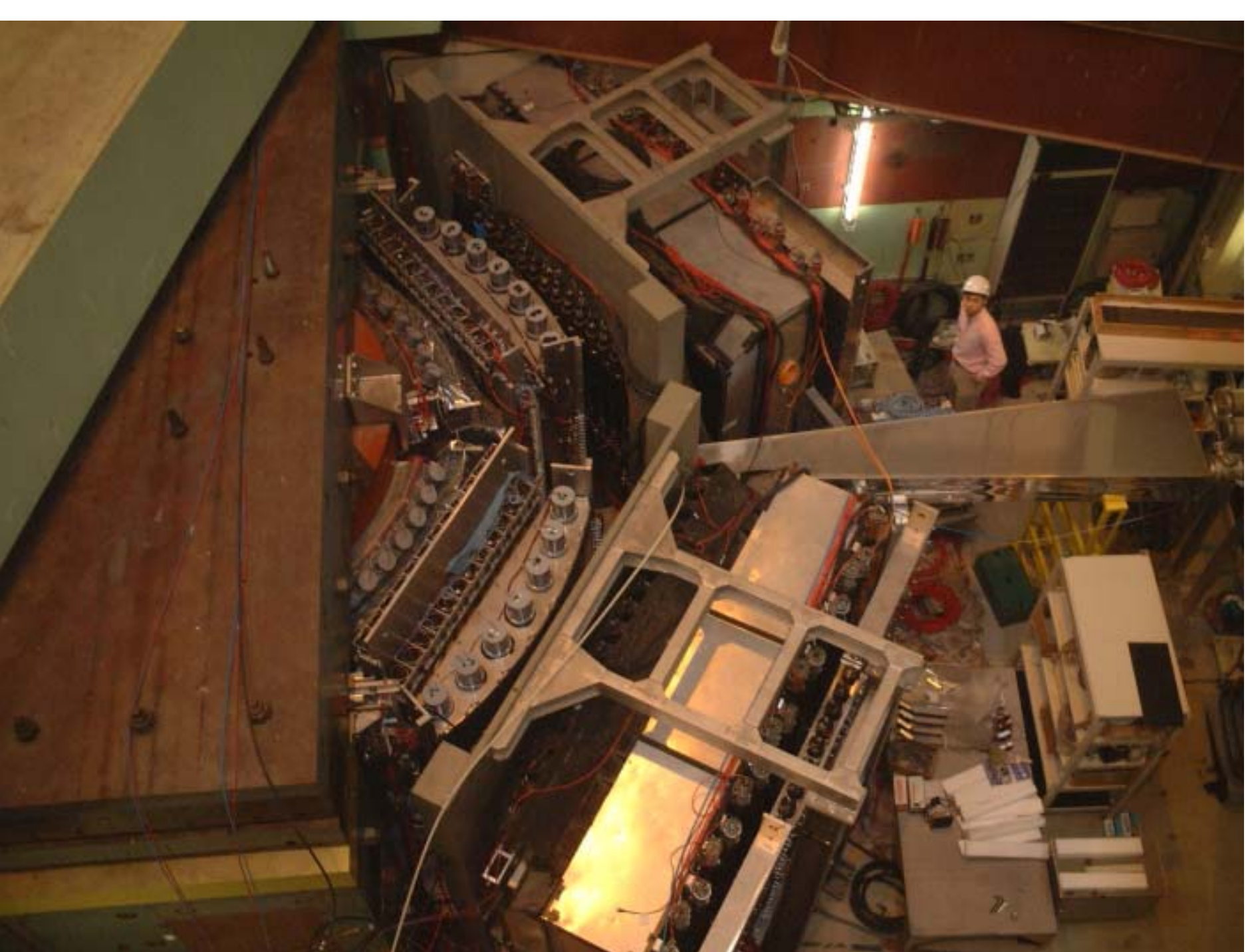


Slowly moving ρ, ω, ϕ ($p_{lab} \sim 2\text{GeV}/c$)
Large Acceptance Spectrometer

Experimental Setup

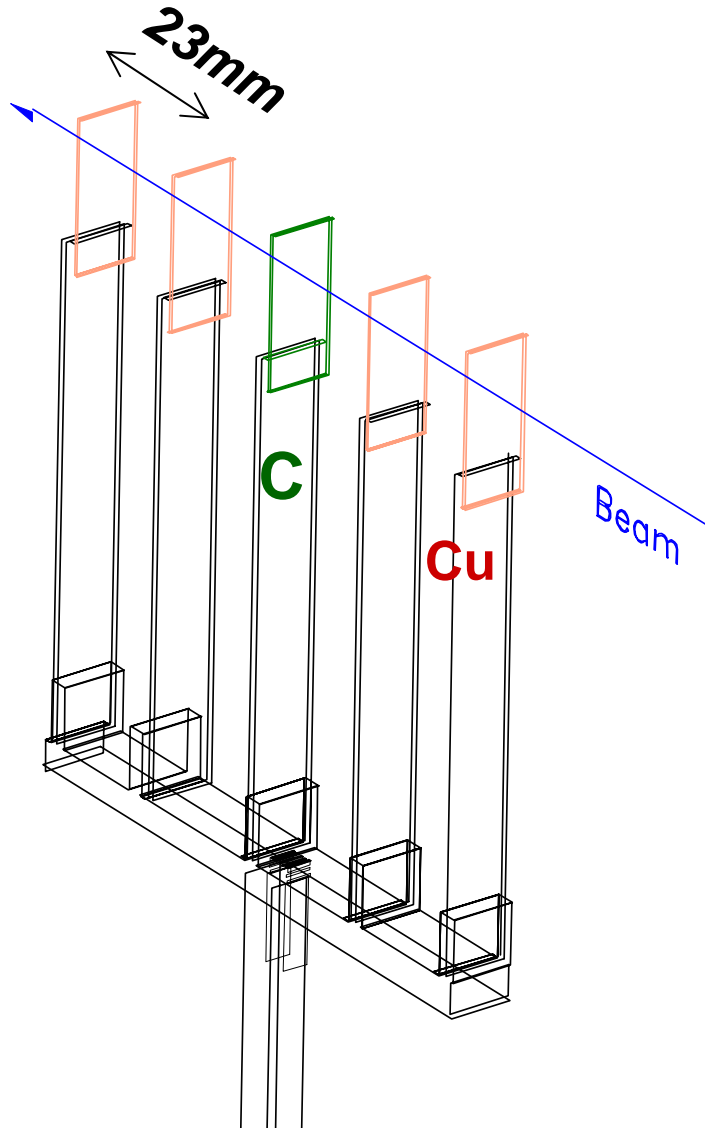
see [poster Instr.3](#)
by F. Sakuma



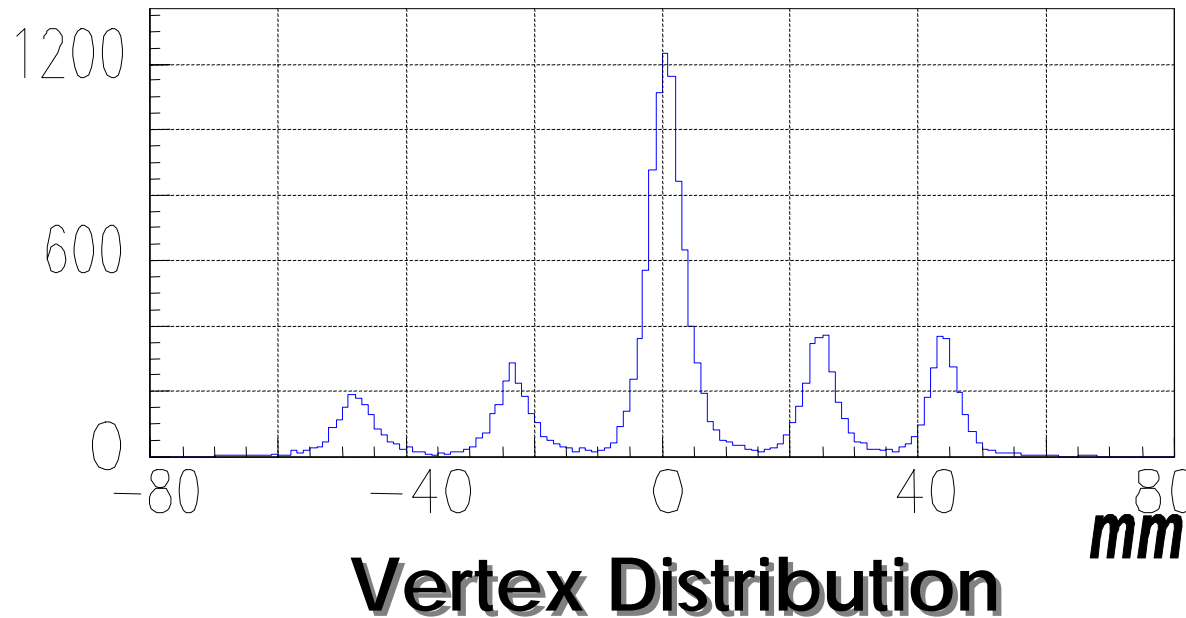


Target

- very thin target with clean and high intensity beam



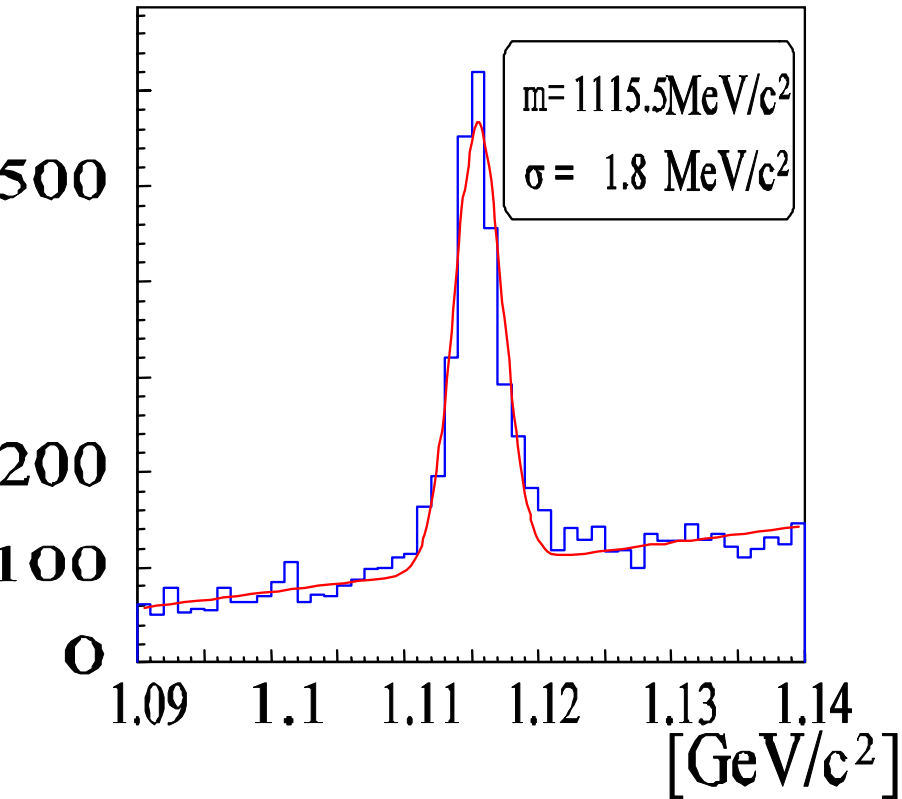
material	beam intensity (p/spill)	Interaction length(%)	radiation length(%)
C	$\sim 1 \times 10^9$	0.2%	0.4%
CuX4	$\sim 1 \times 10^9$	0.05%X4	0.5%X4



Spectrometer Performance

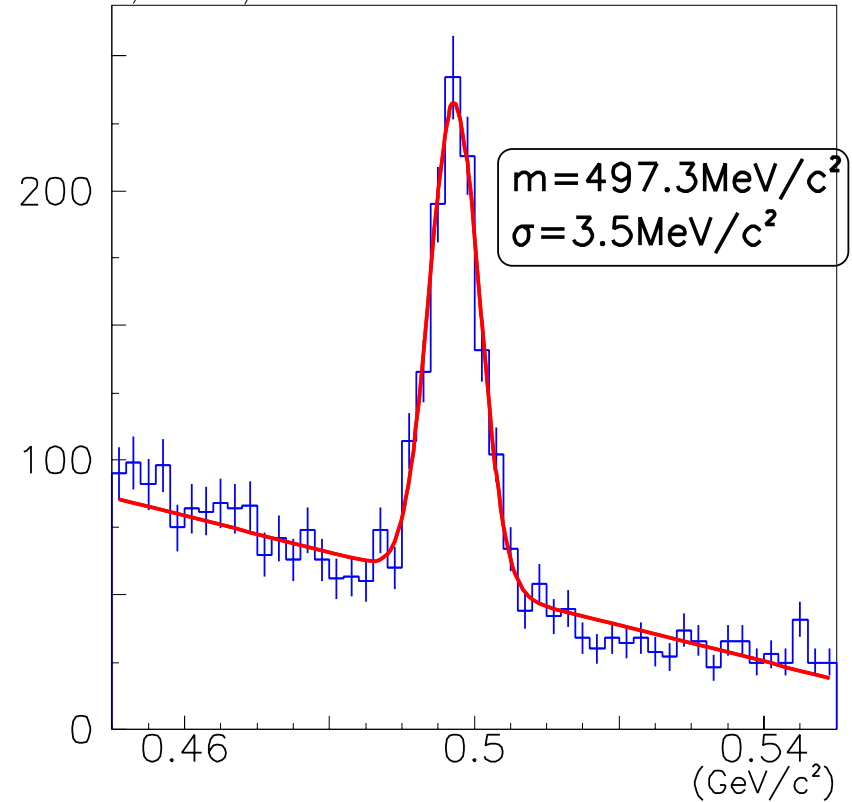
[events / 1MeV/c²]

p -



$M_p = 1115.5 \text{ MeV}/c^2$ (PDG $1115.7 \text{ MeV}/c^2$)
 $\sigma_p = 1.8 \text{ MeV}/c^2$ (Sim. 1.9 MeV)

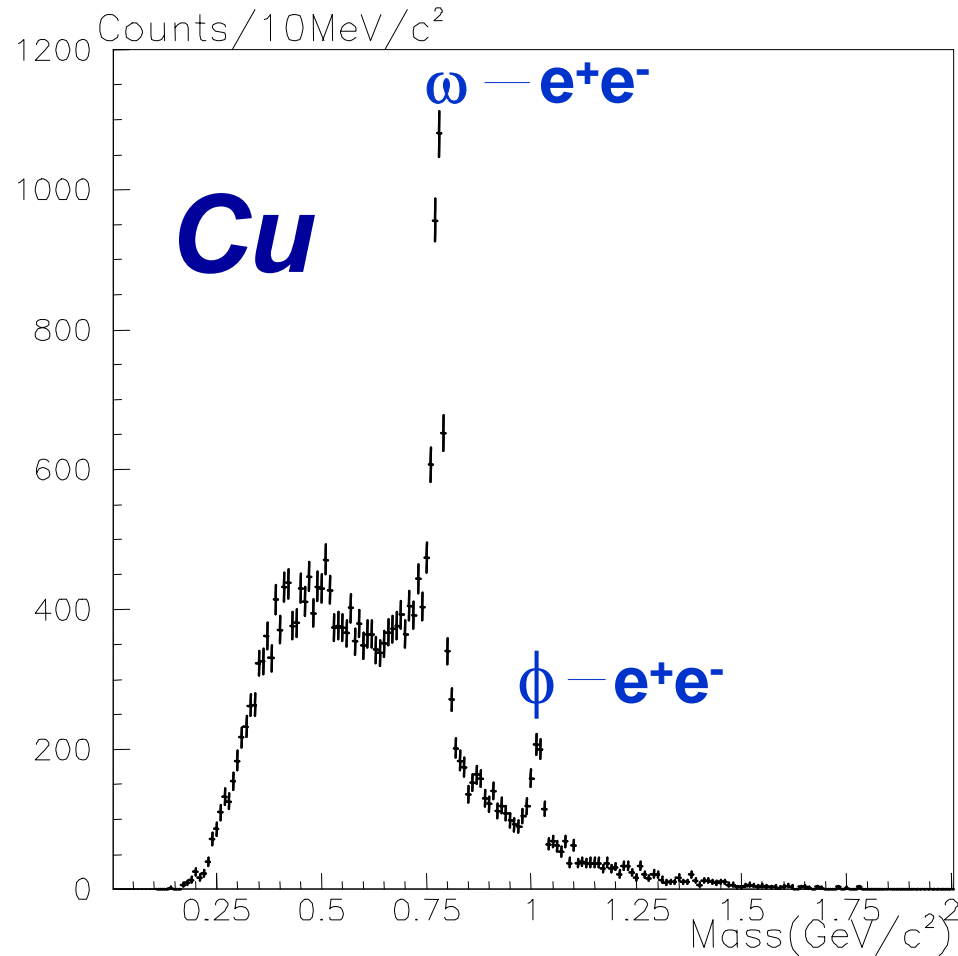
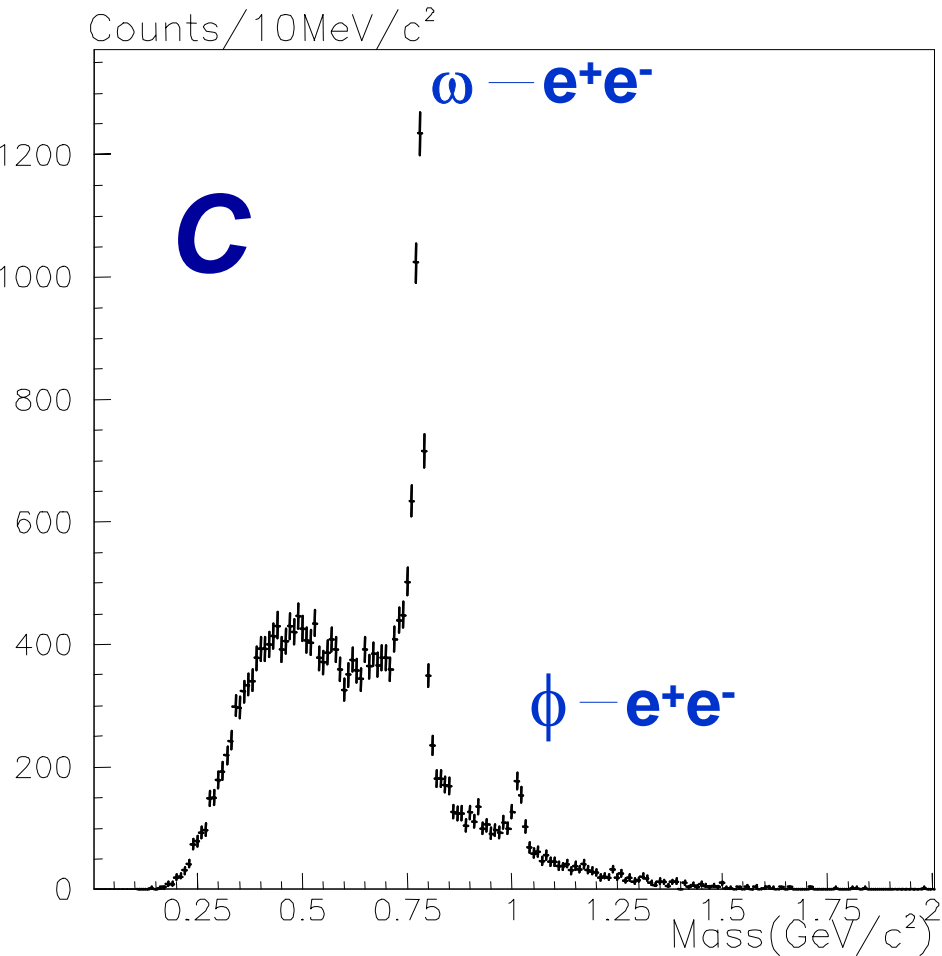
Counts/2MeV/c² **K⁰** + -



$M_K = 497.6 \text{ MeV}/c^2$ (PDG $497.7 \text{ MeV}/c^2$)
 $\sigma_K = 3.8 \text{ MeV}/c^2$ (Sim. 4.1 MeV)

Mass and Width are well reproduced by MC.

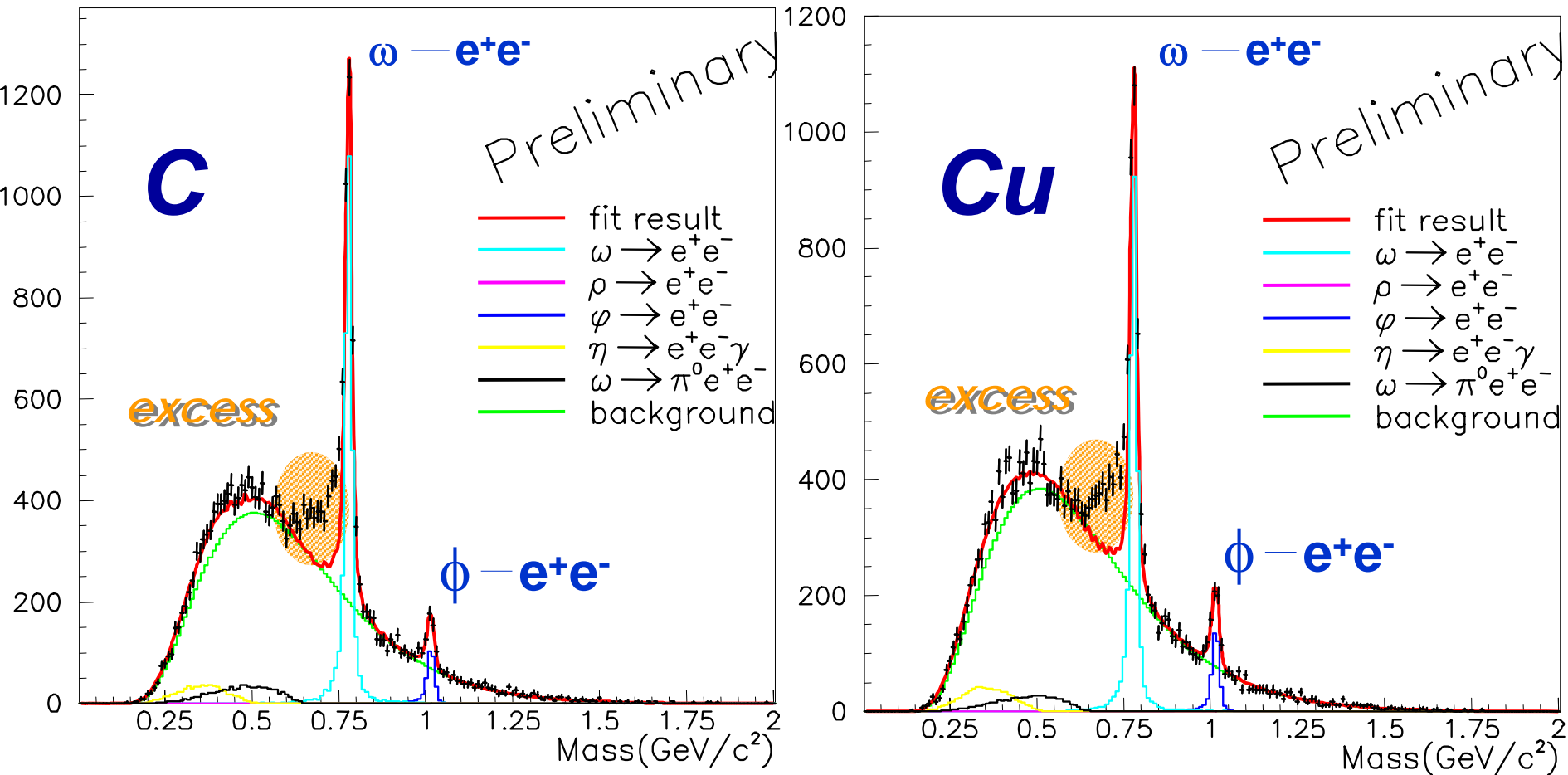
Invariant Mass Spectrum of e^+e^- (2002 data)



On the Fit

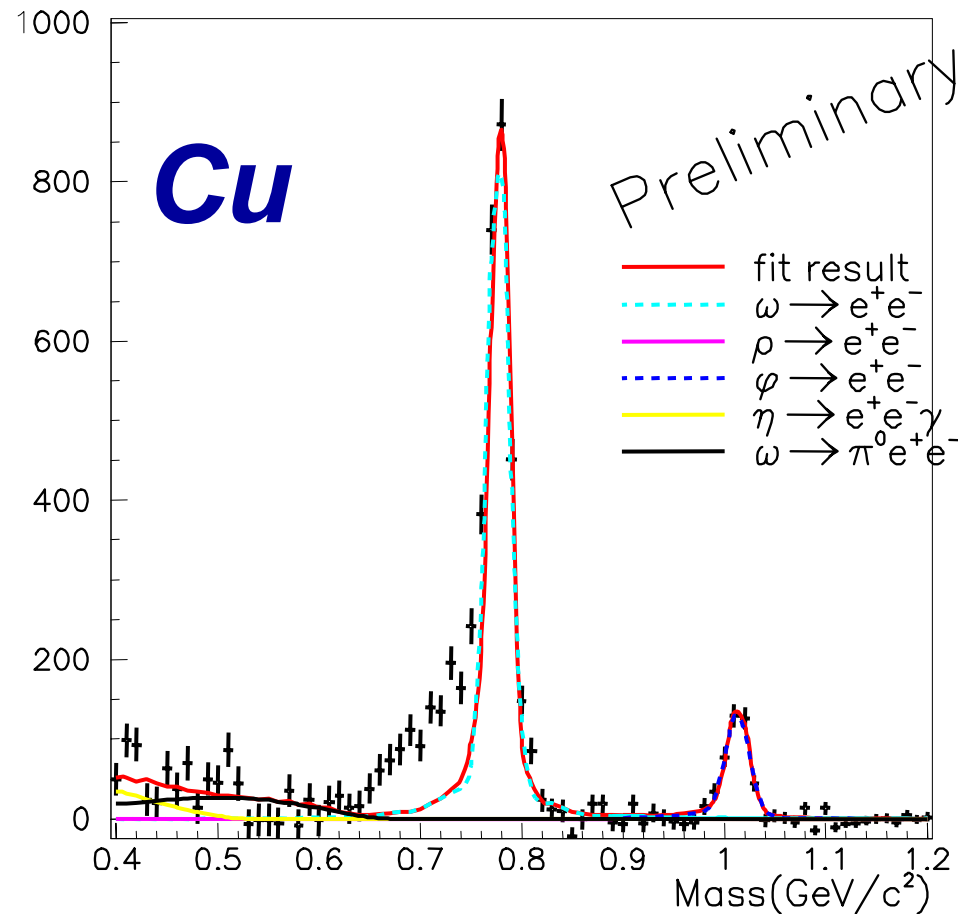
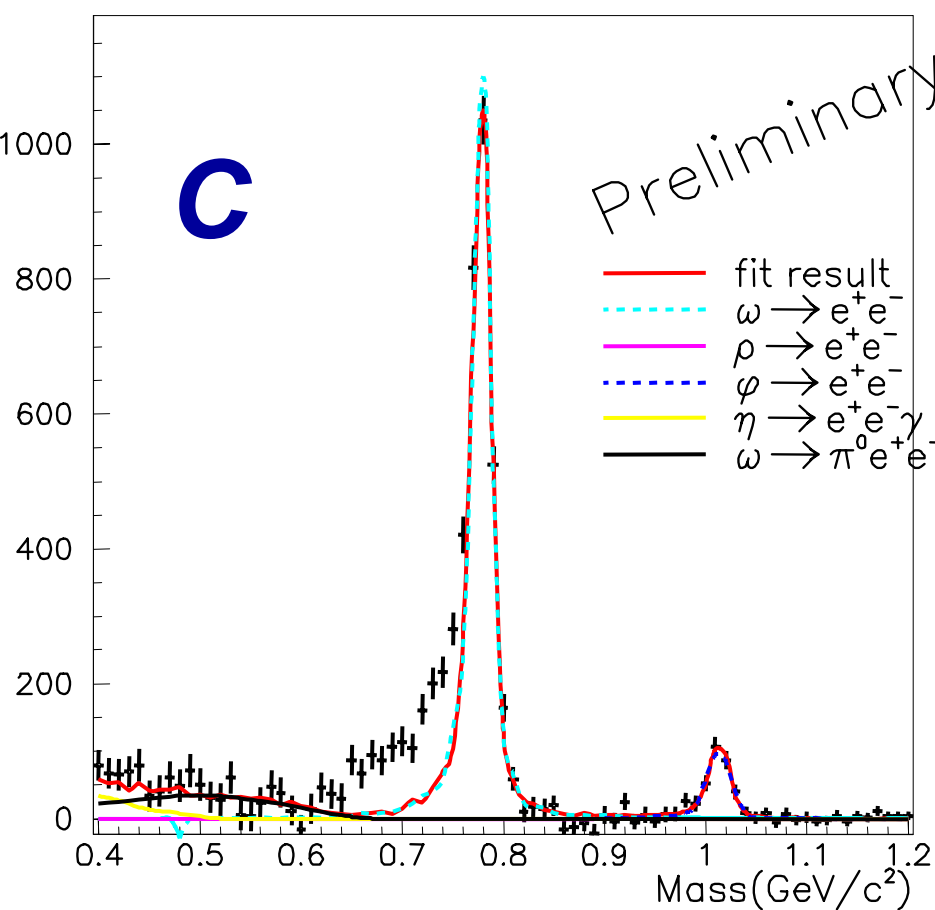
- Resonance
 - Breit-Wigner shape
 - experimental effect estimated by Geant4 simulation – energy loss, mass resolution, mass acceptance etc.
- Background
 - combinatorial background obtained by mixed events
- Relative abundances of mesons (ρ, ω, ϕ) and background are obtained by the fitting.

Invariant Mass Spectrum of e^+e^- (2002 data)



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

Invariant Mass Spectrum of e^+e^- (after subtracting background)



ρ / ω ratio is consistent with zero

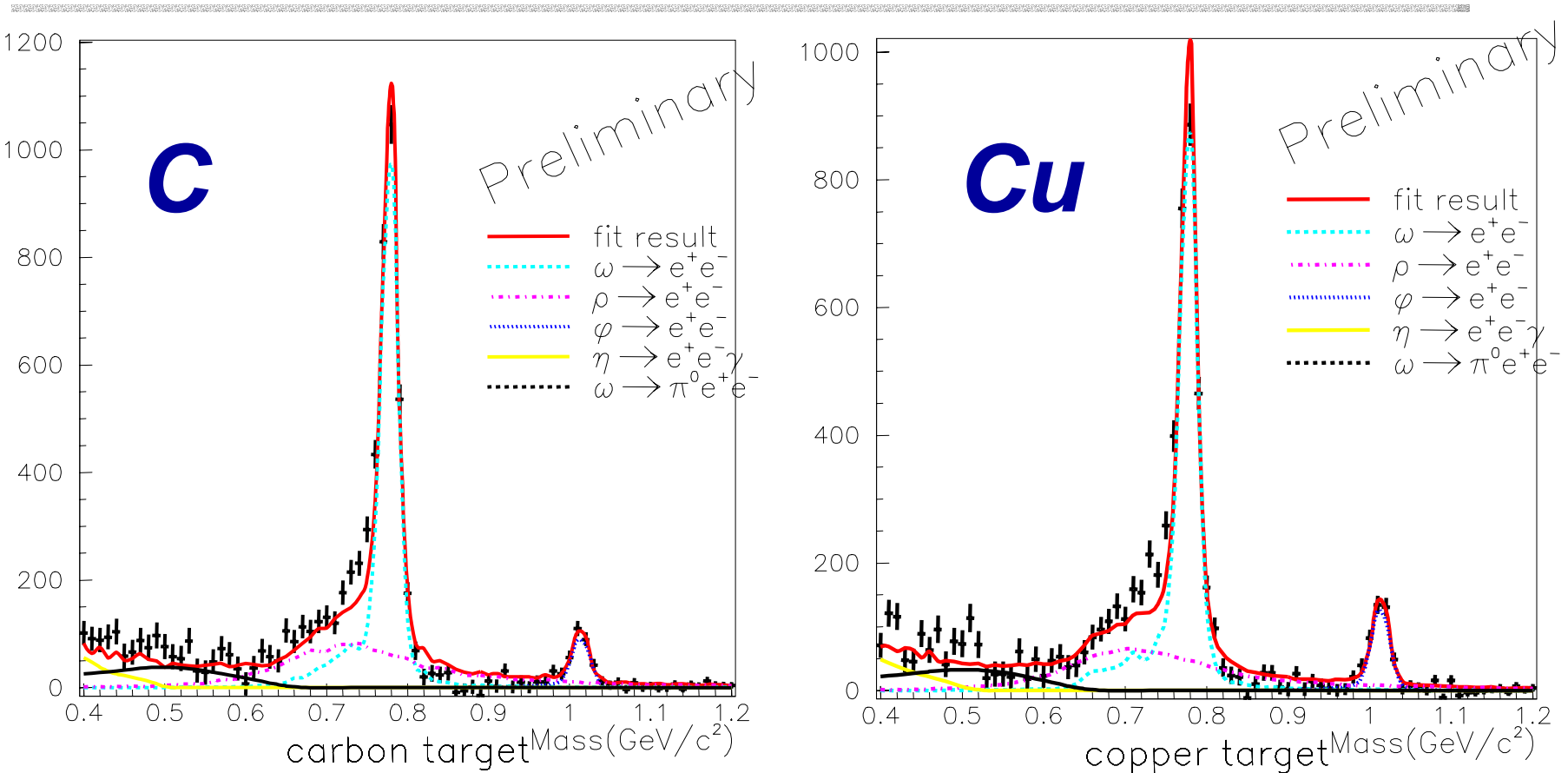
$$0.0 \pm 0.01(\text{stat.}) \pm 0.2(\text{sys.})$$

$$0.0 \pm 0.05 \pm 0.5$$

The excess can be understood as modified ρ mesons.

Model Calculation

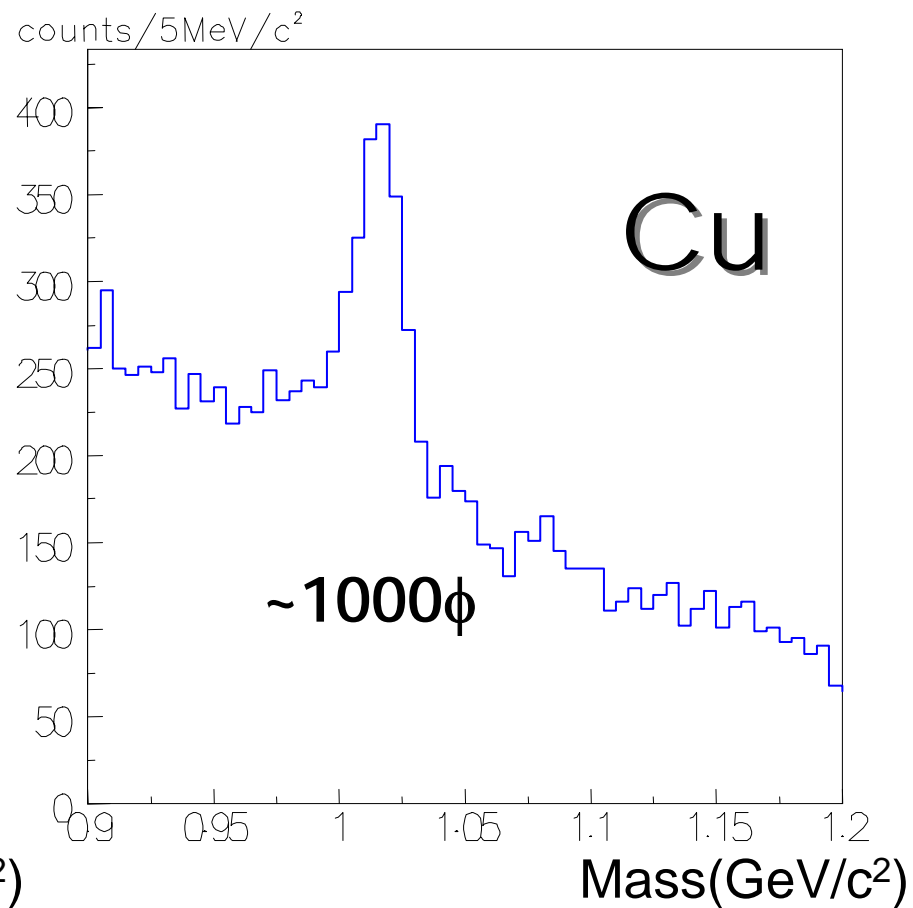
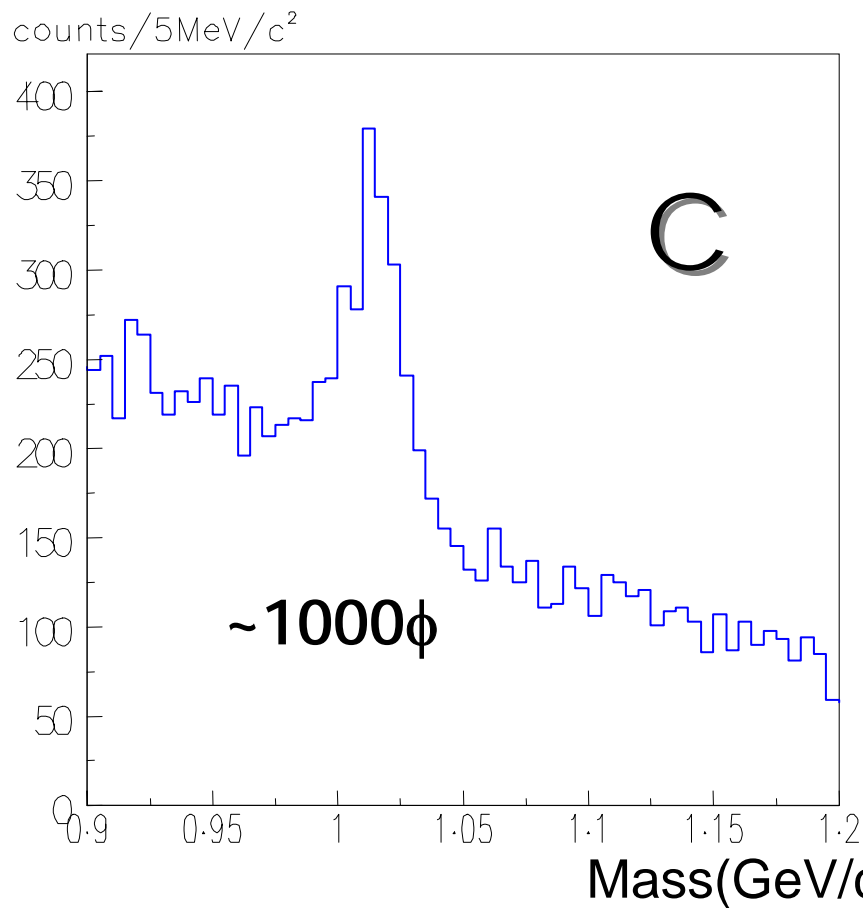
With the formula : $m^*/m=1-0.16\rho/\rho_0$



- generate on surface of forward hemisphere of the nucleus
- spectral function : Breit-Wigner + mass modification.

Invariant Mass Spectrum of

$$\phi \rightarrow e^+e^-$$



Work in progress

Summary

- KEK PS-E325 experiment measured e^+e^- and K^+K^- pairs to investigate invariant mass of vector mesons decaying in nuclear matter.
- In 2002 e^+e^- data, we have observed the **excess over the known hadronic sources** below the ω peak. Obtained ρ / ω ratio indicates that this excess is mainly due to the **modification of ρ mesons**.
- Model calculation well reproduced the tendency of data.
- Analysis on phi meson is now in progress.