

# Measurement of Invariant Mass Spectra of Vector Meson Decaying in Nuclear Matter at KEK-PS

---

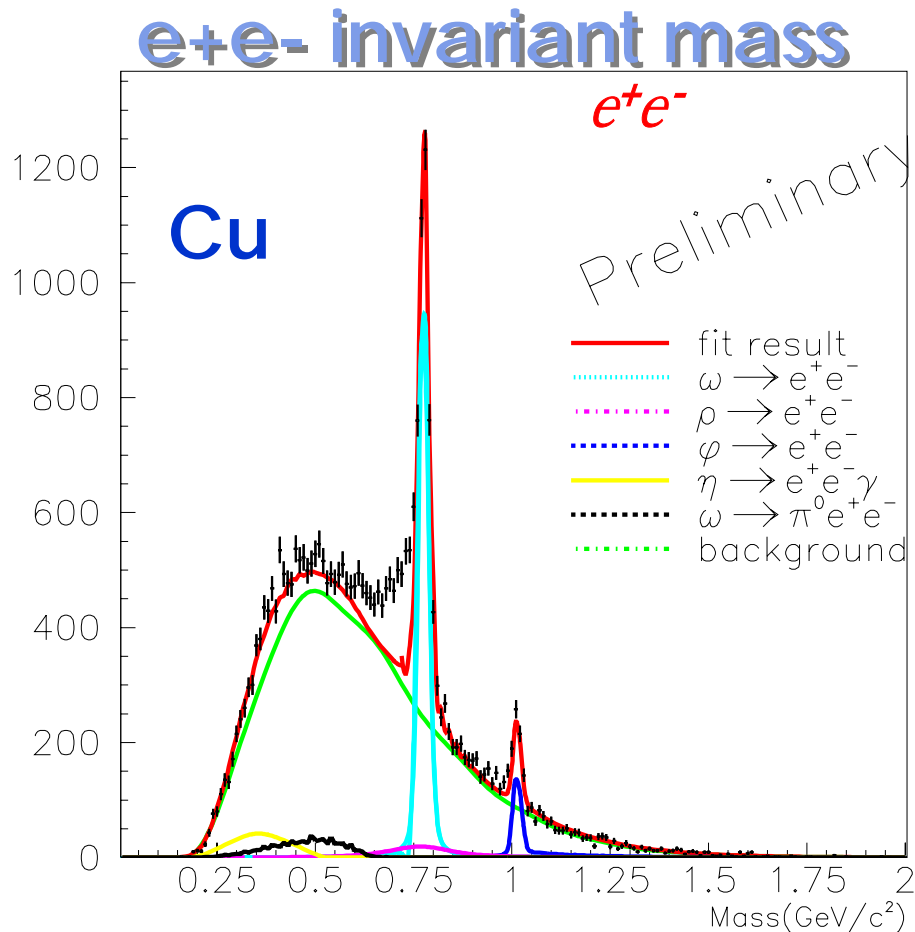
Kyoto Univ.<sub>a</sub> , KEK<sub>b</sub>, RIKEN<sub>c</sub>, CNS Univ. of Tokyo<sub>d</sub>,  
ICEPP Univ. of Tokyo<sub>e</sub>, Tohoku Univ.<sub>f</sub>

Ryotaro Muto, RIKEN, Japan

J. Chiba<sub>b</sub>, H. En'yo<sub>c</sub>, Y. Fukao<sub>a</sub>, H. Funahashi<sub>a</sub>, H. Hamagaki<sub>d</sub>, M. Ieiri<sub>b</sub>,  
M. Ishino<sub>e</sub>, H. Kanda<sub>f</sub> , M. Kitaguchi<sub>a</sub>, S. Mihara<sub>e</sub>, K. Miwa<sub>a</sub>, T. Miyashita<sub>a</sub>,  
T. Murakami<sub>a</sub>, T. Nakura<sub>a</sub>, M. Nomachi<sub>b</sub>, K. Ozawa<sub>d</sub>, F. Sakuma<sub>a</sub>,  
O. Sasaki<sub>b</sub>, H.D. Sato<sub>a</sub>, M. Sekimoto<sub>b</sub>, T. Tabaru<sub>c</sub>, K.H. Tanaka<sub>b</sub>,  
M. Togawa<sub>a</sub>, S. Yadama<sub>a</sub>, S. Yokkaichi<sub>c</sub>, Y. Yoshimura<sub>a</sub>  
(KEK-PS *E325* Collaboration)

# Abstract

We have measured  $e^+e^-$  and  $K^+K^-$  invariant mass spectra to investigate in-medium mass modification of vector mesons.



## -Contents-

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

# Physics Motivation

## Effective Mass of Quarks

**In Vacuum**

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

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

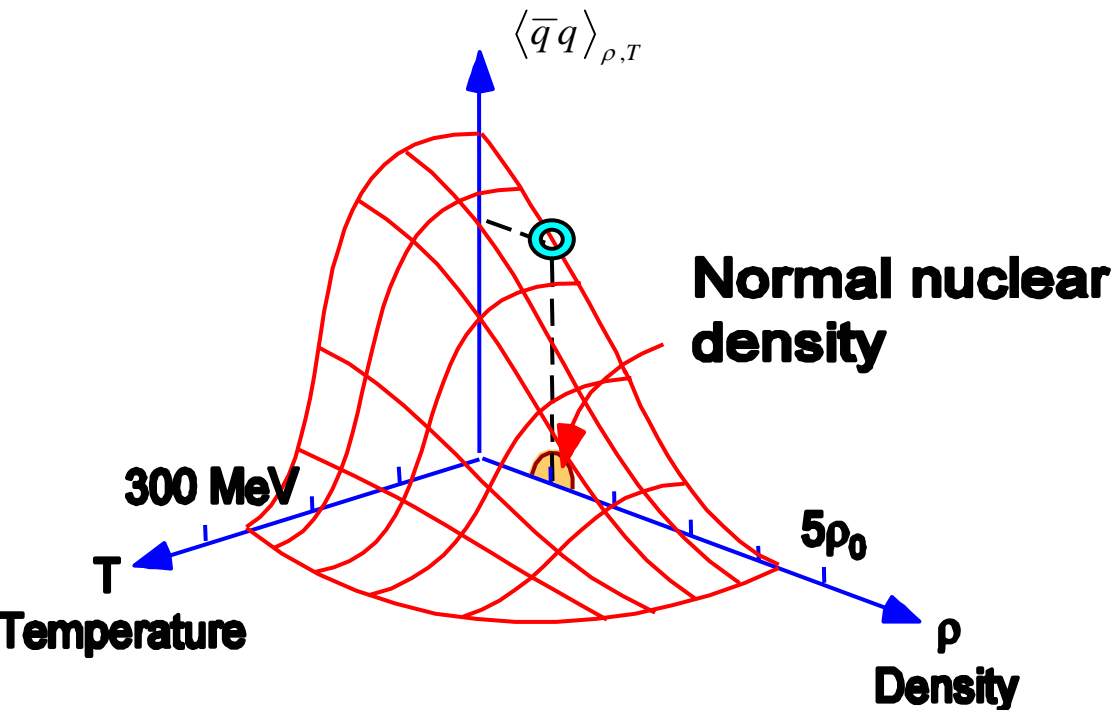


*Spontaneous Breaking  
of Chiral Symmetry*

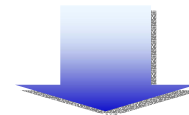
**At High  $\rho / T$**

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

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



How to measure ?



Using Vector Mesons

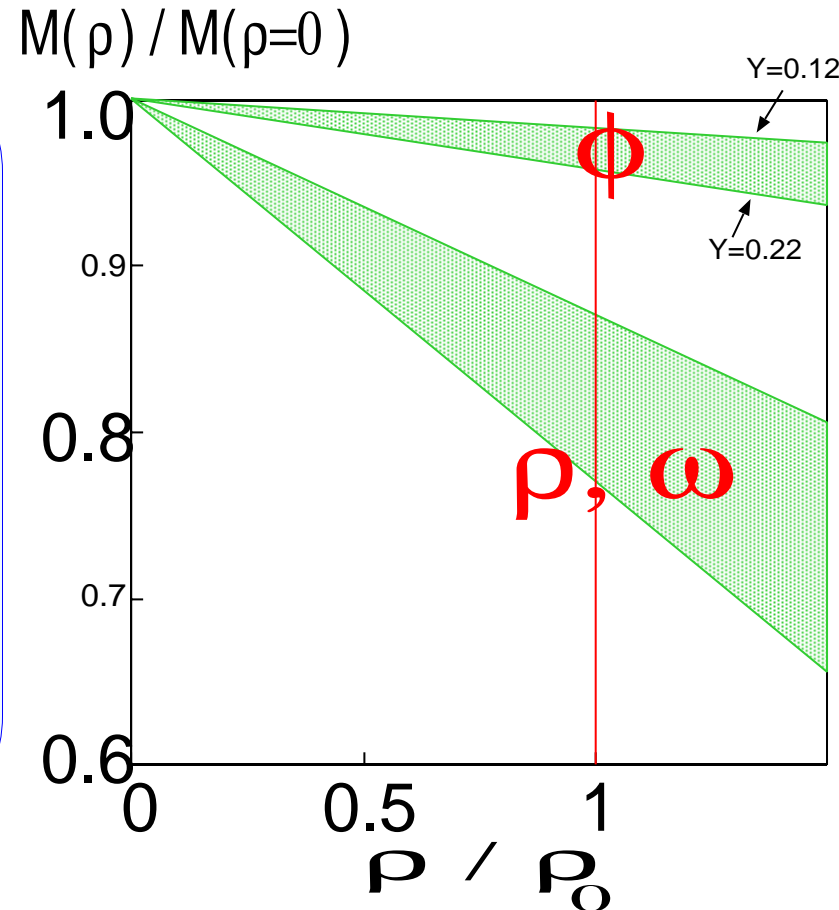
# Vector Meson

## Mass of Vector Meson

$$2 \times M_q + \text{small interaction term}$$

Hatsuda & Lee P.R.C 1992

- large mass modification  $\sim 150\text{MeV}$  at  $\rho = 0$
- large cross section
- mass modification  $20 \sim 40\text{MeV}$
- small decay width ( $4.4\text{MeV}/c^2$ ) sensitive to mass modification

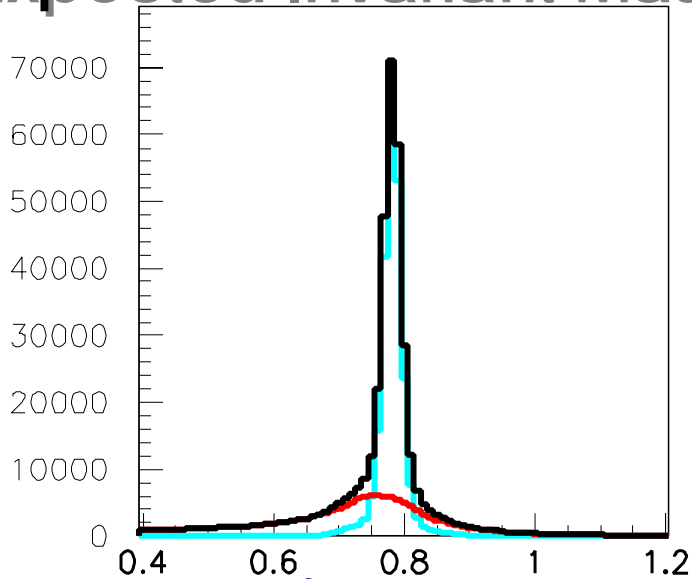


# What we measure

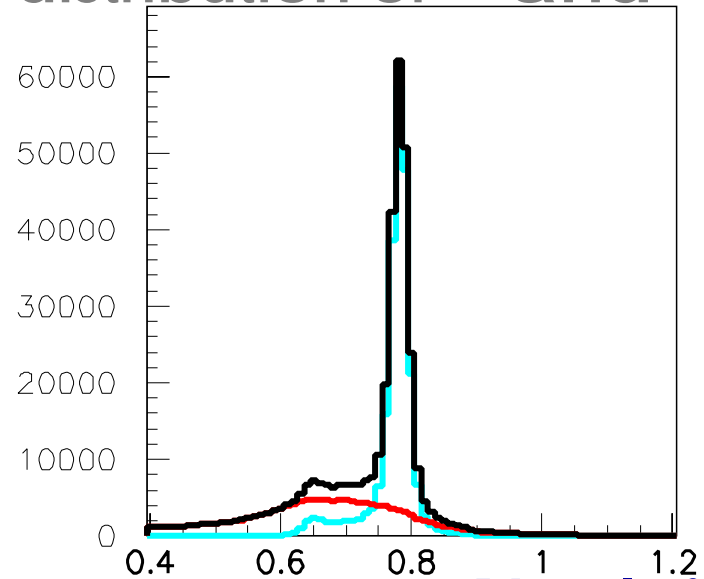
In 12GeV p + A , , + X

Invariant Mass of  $e^+e^-$ ,  $K^+K^-$

Expected Invariant Mass distribution of and



Decay in vacuum

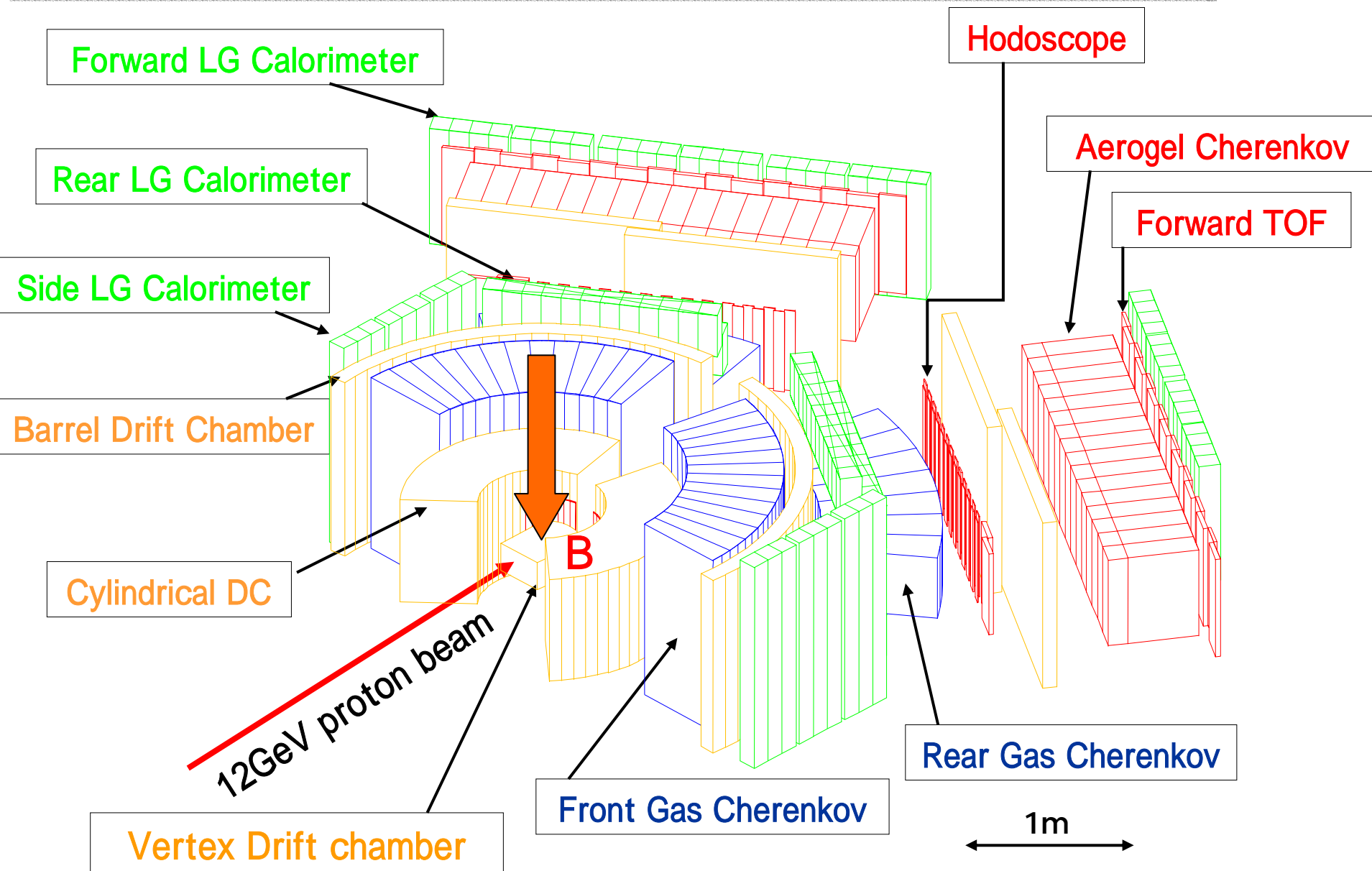


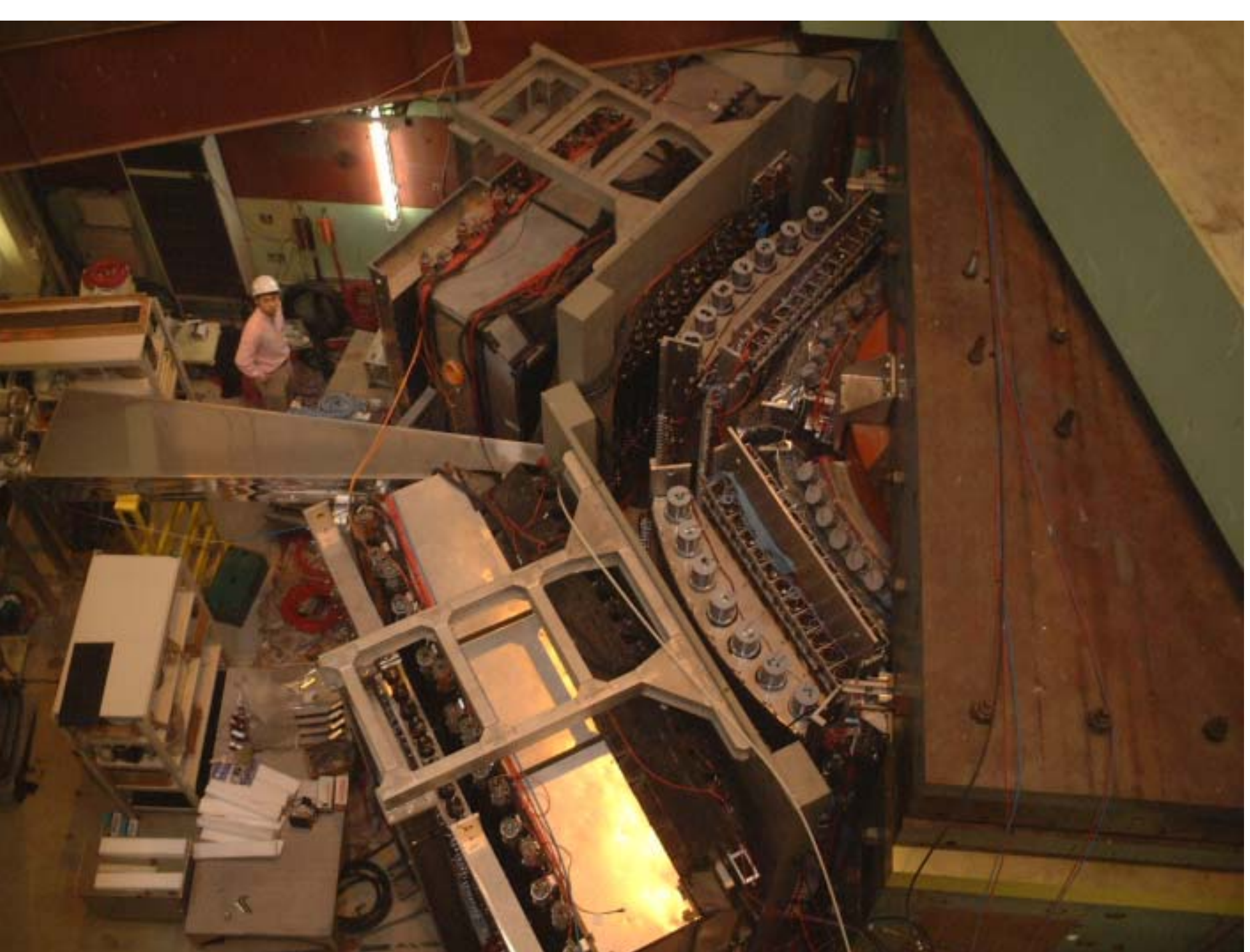
In Copper Nuclei

Slowly moving , , ( $p_{lab} \sim 2\text{GeV}/c$ )

Large Acceptance Spectrometer

# Experimental Setup

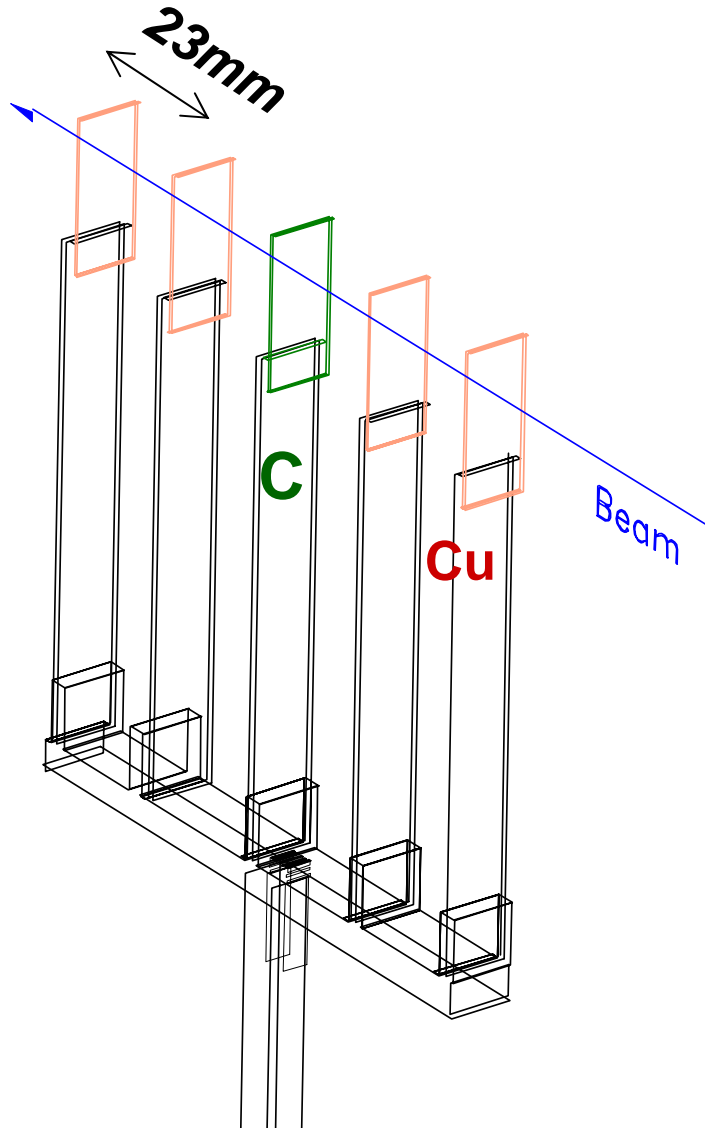




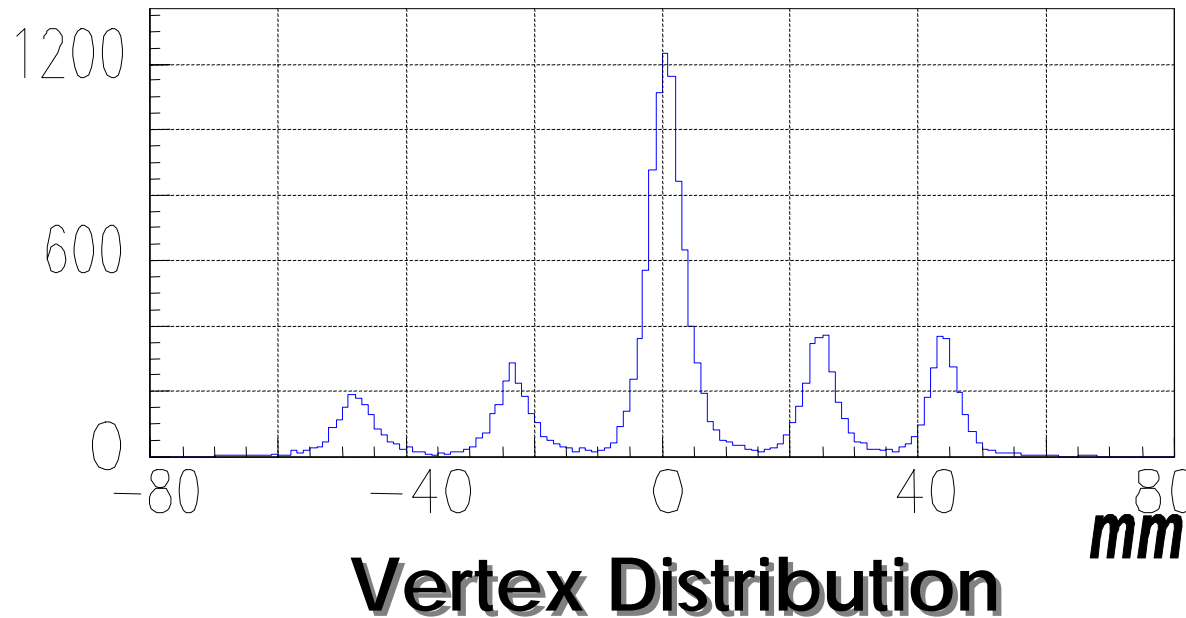


# Target

- 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

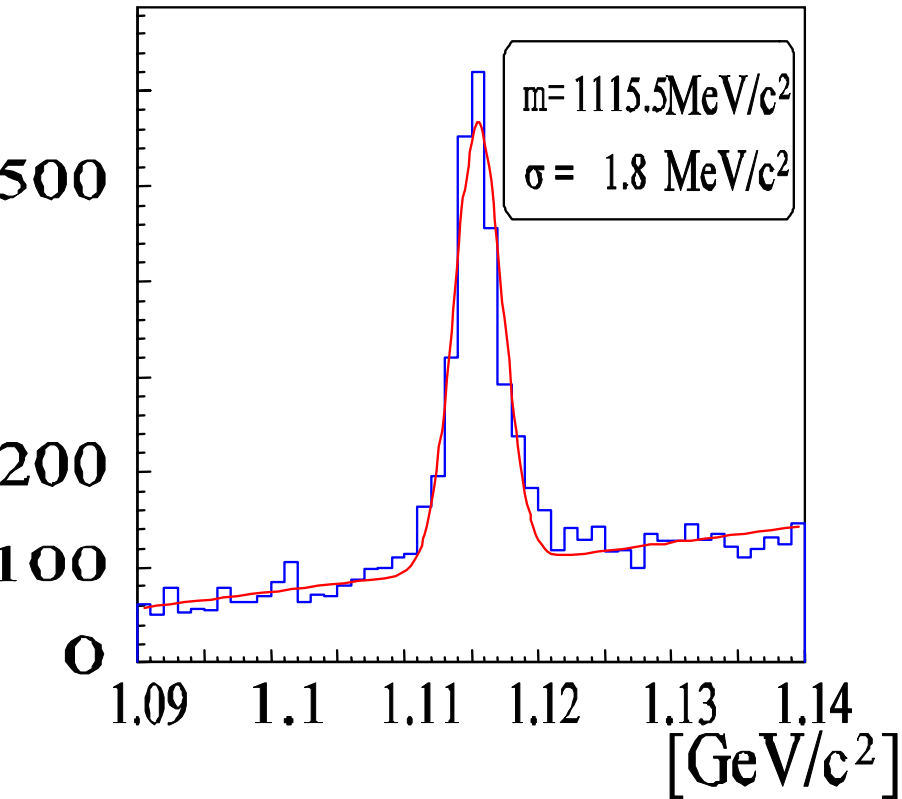




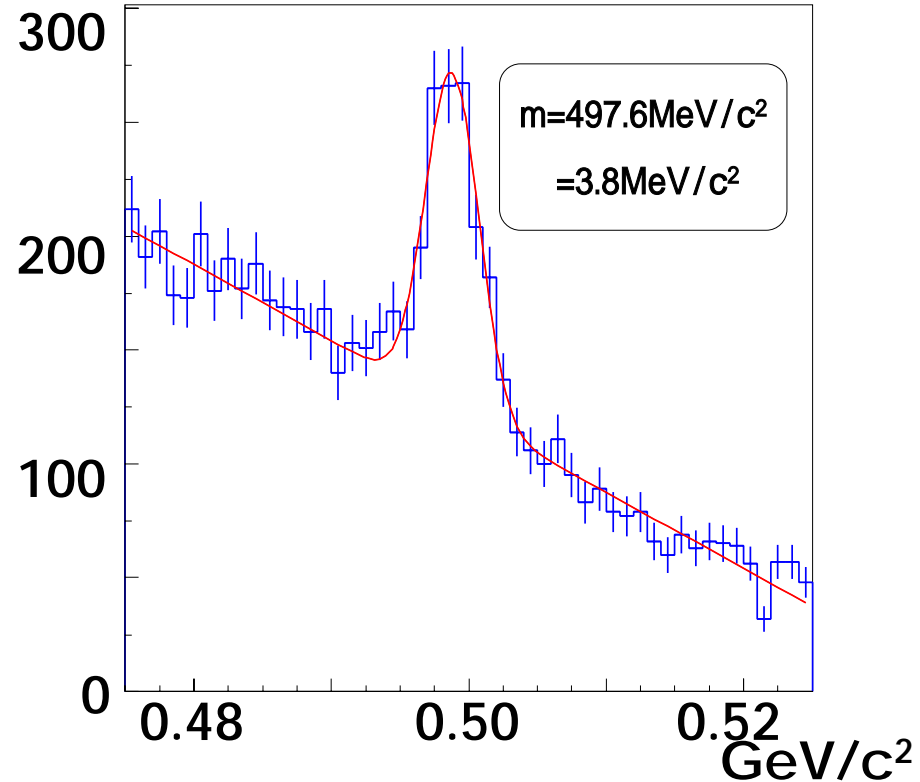
# Spectrometer Performance

[events / 1MeV/c<sup>2</sup>]

p<sup>-</sup>



K<sup>0</sup> + -

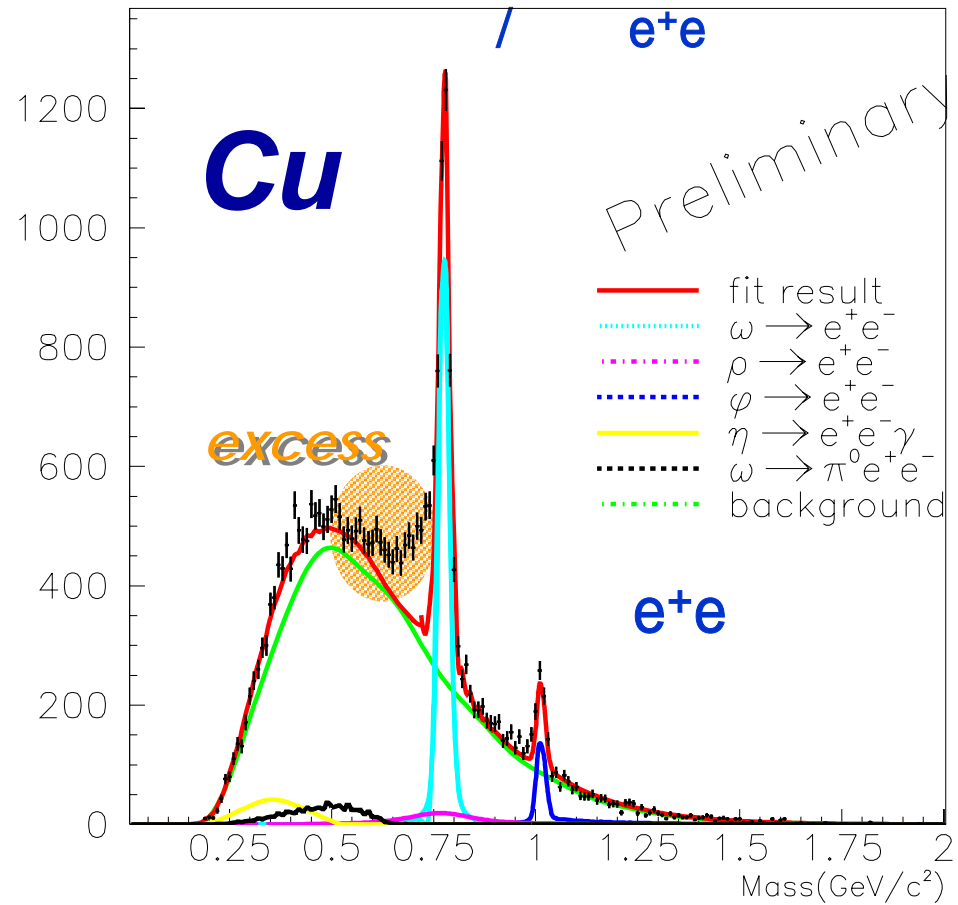
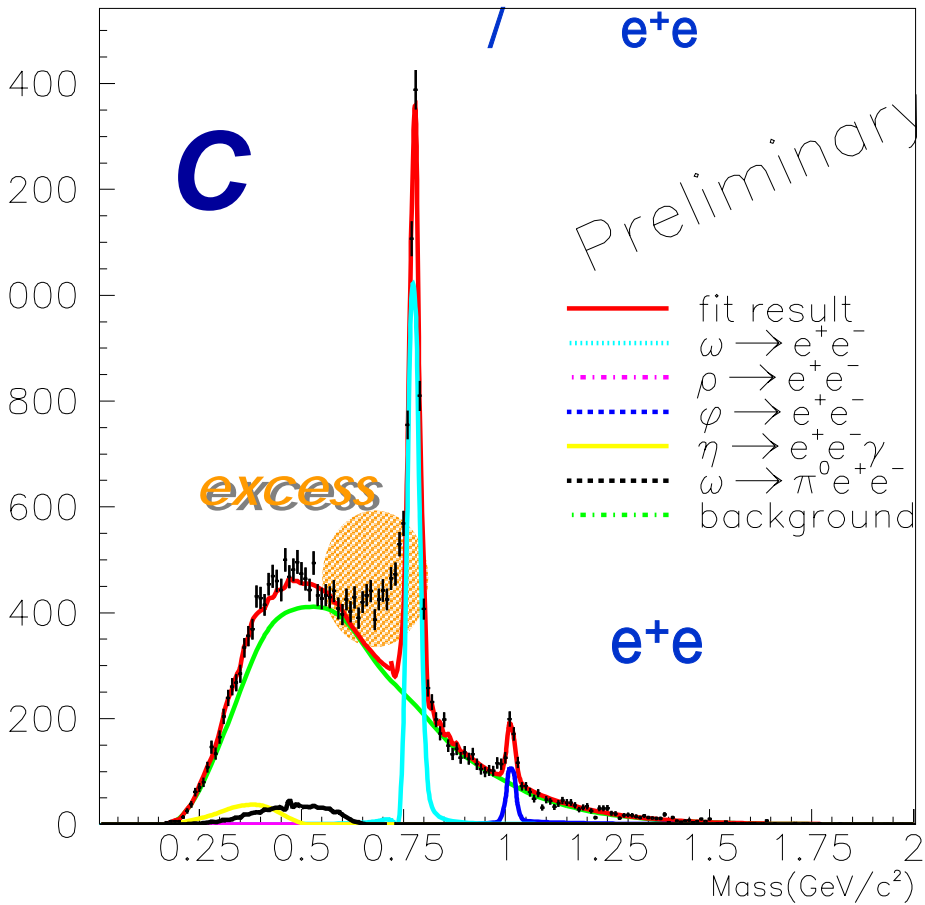


$M = 1115.5 \text{ MeV}/c^2$  (PDG  $1115.7 \text{ MeV}/c^2$ )  
 $\sigma = 1.8 \text{ MeV}/c^2$  (Sim.  $1.9 \text{ MeV}$ )

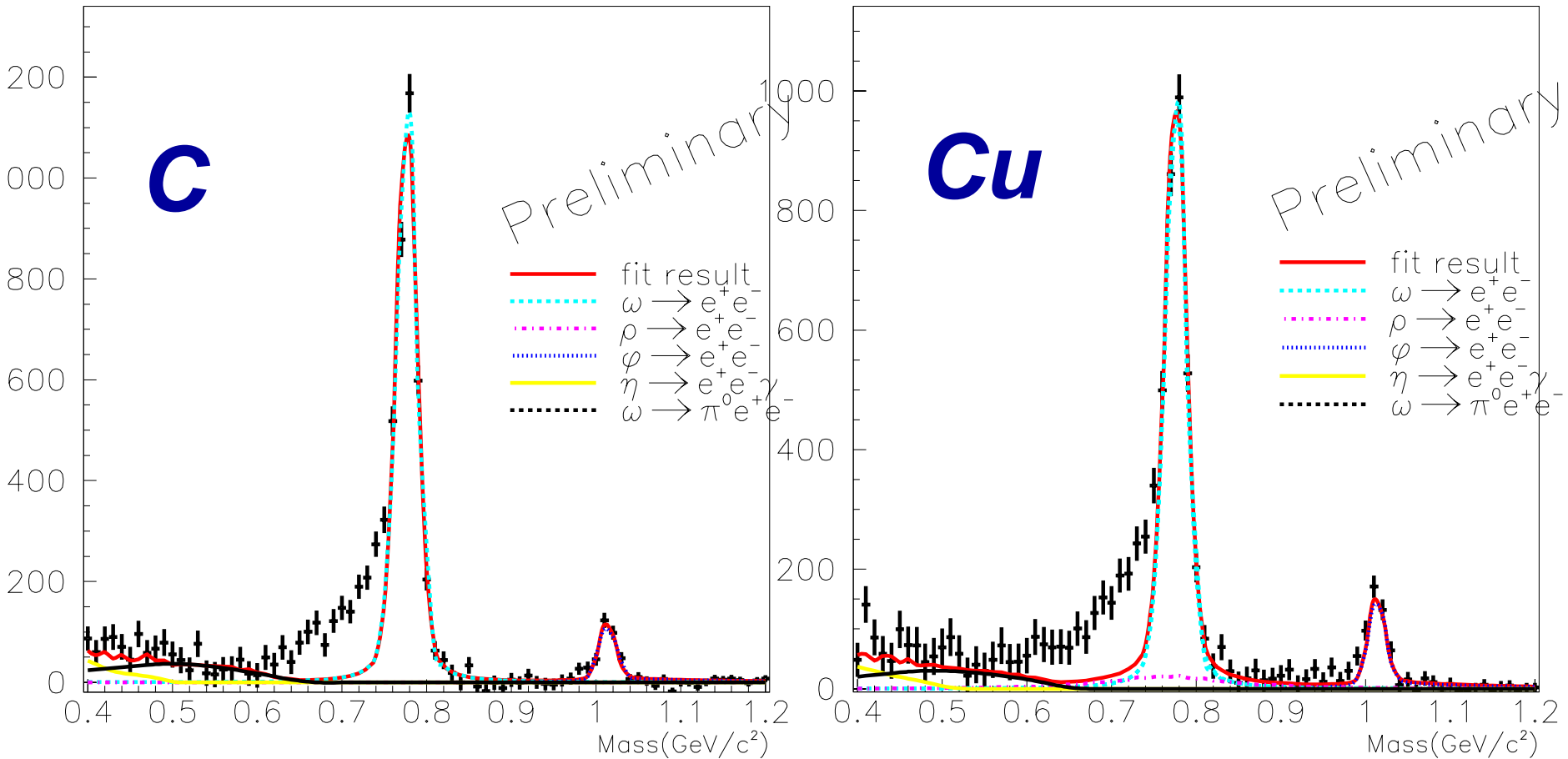
$M_K = 497.6 \text{ MeV}/c^2$  (PDG  $497.7 \text{ MeV}/c^2$ )  
 $\kappa = 3.8 \text{ MeV}/c^2$  (Sim.  $4.1 \text{ MeV}$ )

Mass and Width are well reproduced by MC.

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



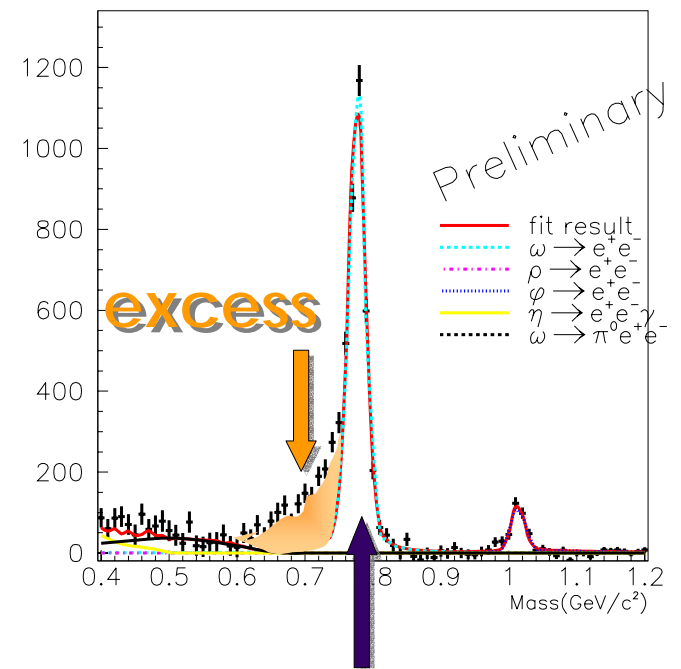
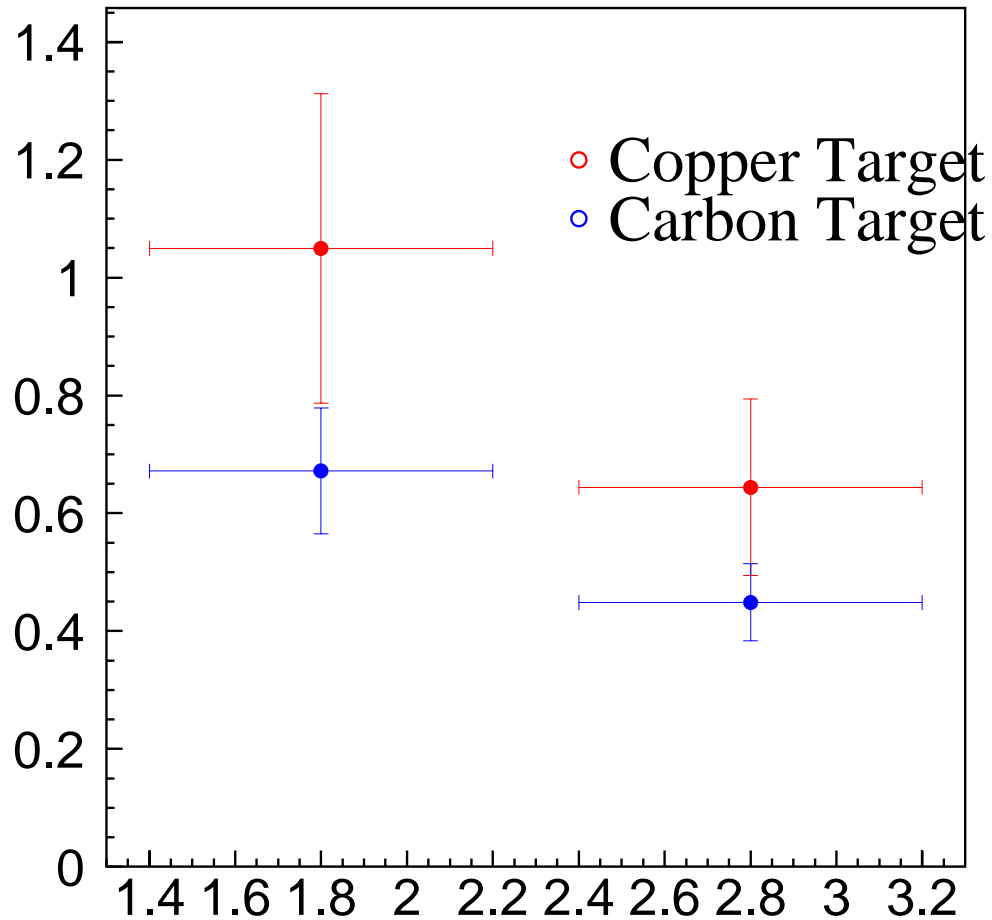
# Invariant Mass Spectrum of $e^+e^-$ (2002 data)



/ ratio is consistent with zero

# Velocity & Nuclear Size Dependence of the Excess

Excess/ ratio



# 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 peak. Obtained  $\sigma/\sigma_0$  ratio indicates that this excess is mainly due to the **modification of mesons**.
- Velocity dependence & nuclear size dependence are shown.