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

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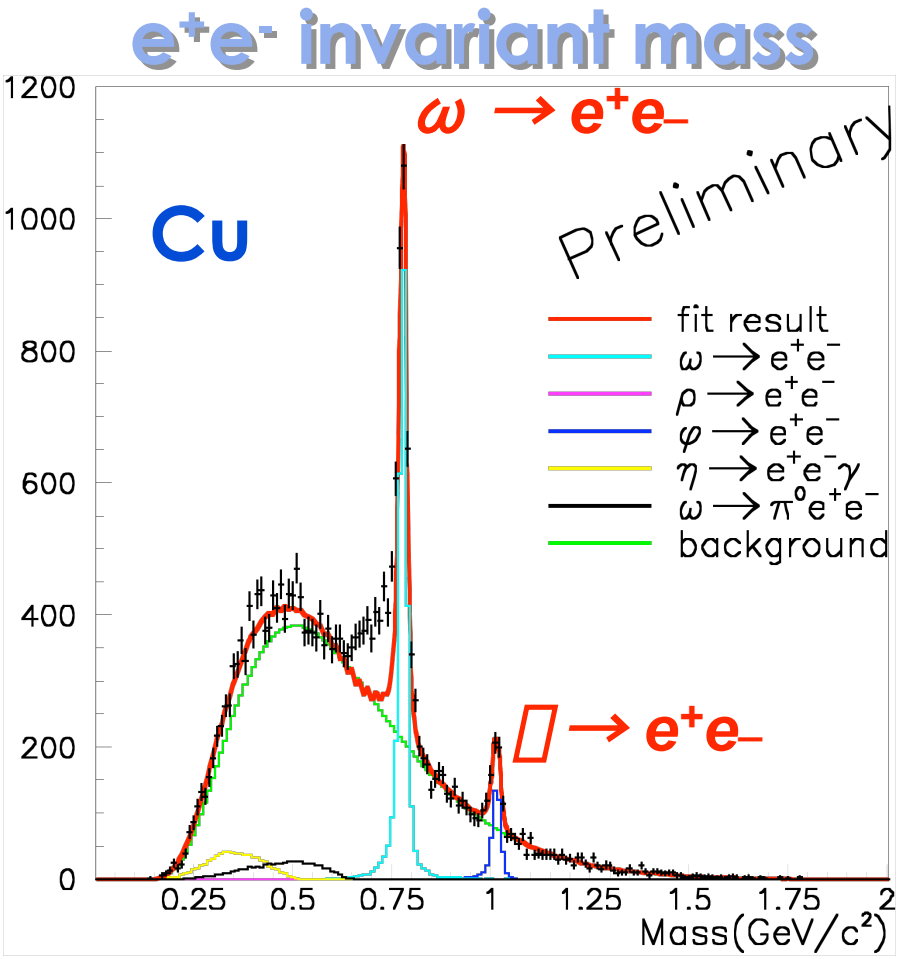
(KEK-PS *E325* Collaboration)

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 12GeV p+A→□,□,□ + X reactions.



-Contents-

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

Physics Motivation

Effective Mass of Quarks

In Vacuum

$m_u \approx m_d \approx 300 MeV$

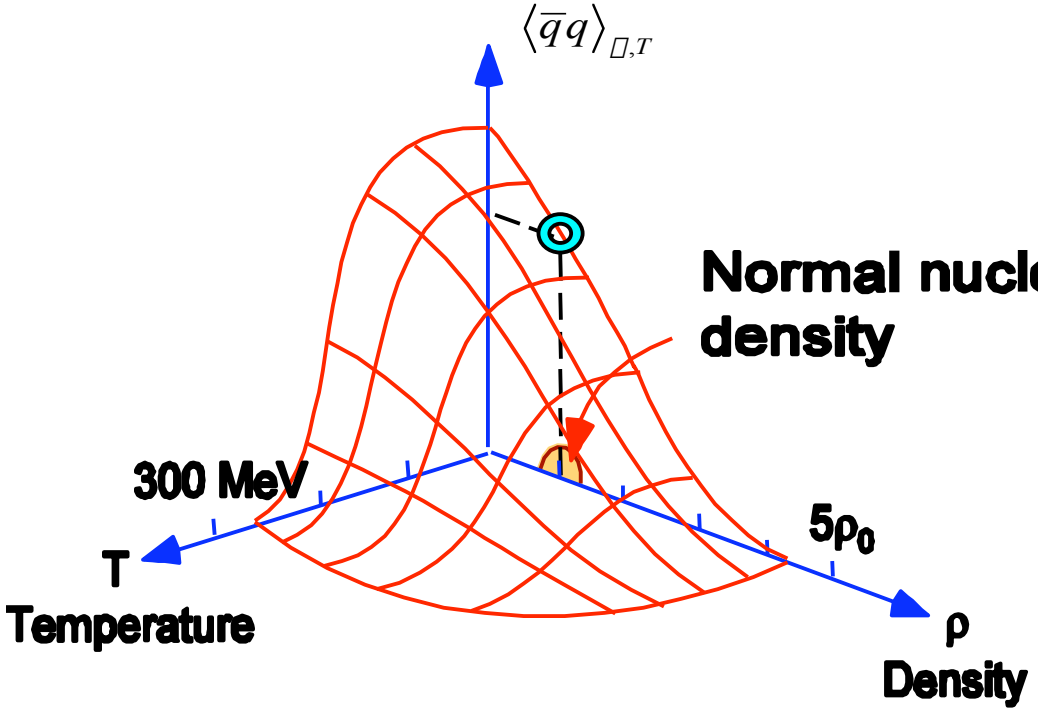
$m_s \approx 500 MeV$

Spontaneous Breaking of Chiral Symmetry

At High T

$m_u \approx m_d \approx 5 MeV$

$m_s \approx 150 MeV$



How to measure =

Using Vector Mesons

Vector Meson

Mass of Vector Meson □, □, □

= 2 x Mq + small interaction term

Hatsuda & Lee P.R.C 1992

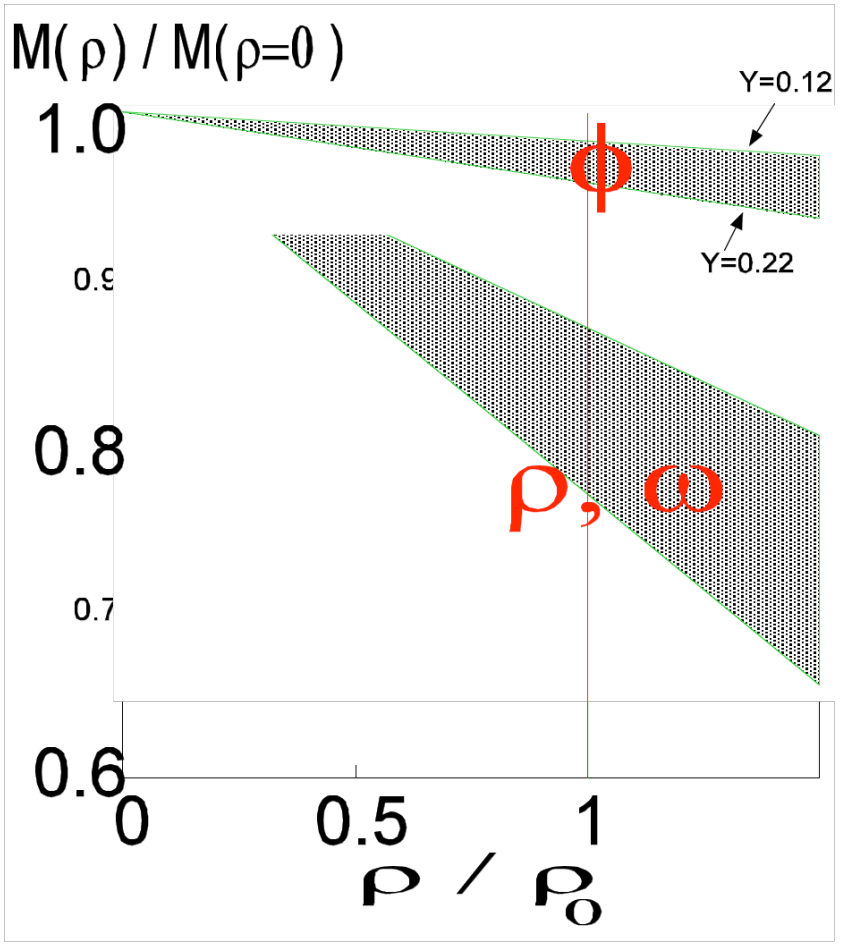
□, □

- large mass modification
  150MeV at □ = □0
- large cross section

□

- mass modification 20 ~ 40MeV
- small decay width (4.4MeV/c²)

sensitive to mass modification



Expected Signal

In 12GeV p + A → □, □, □ + X

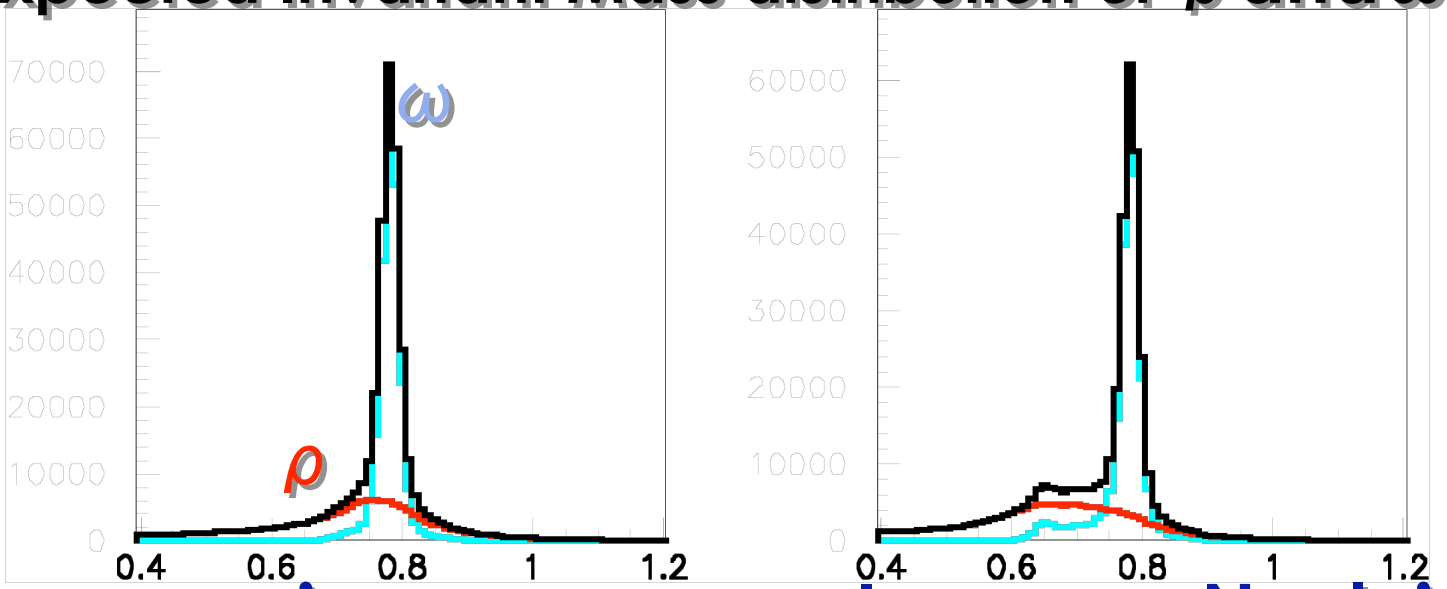
Invariant Mass of e^+e^-, K^+K^-

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



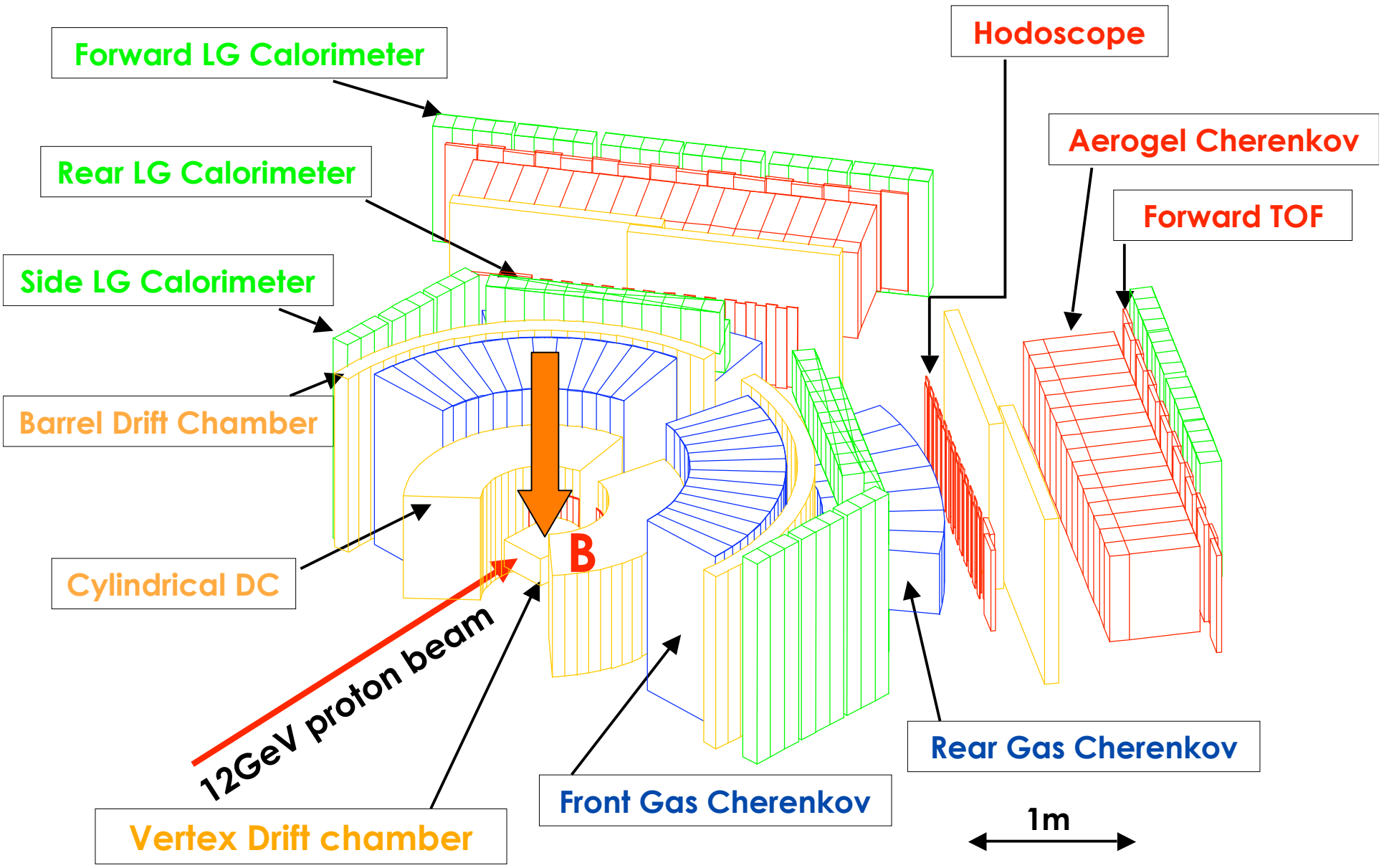
Decay in vacuum **In Copper Nuclei**

Slowly moving □, □, □ (p_{lab}～2GeV/c)

_ Large Acceptance Spectrometer

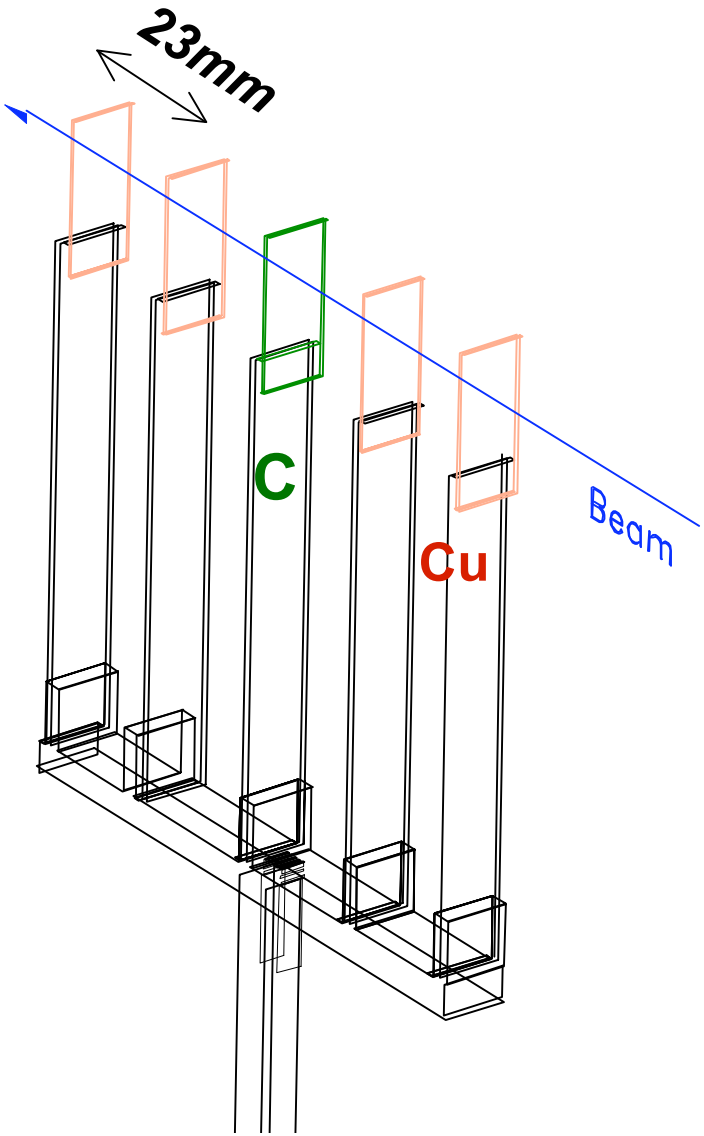
Experimental Setup

see poster Instr.3
by F. Sakuma

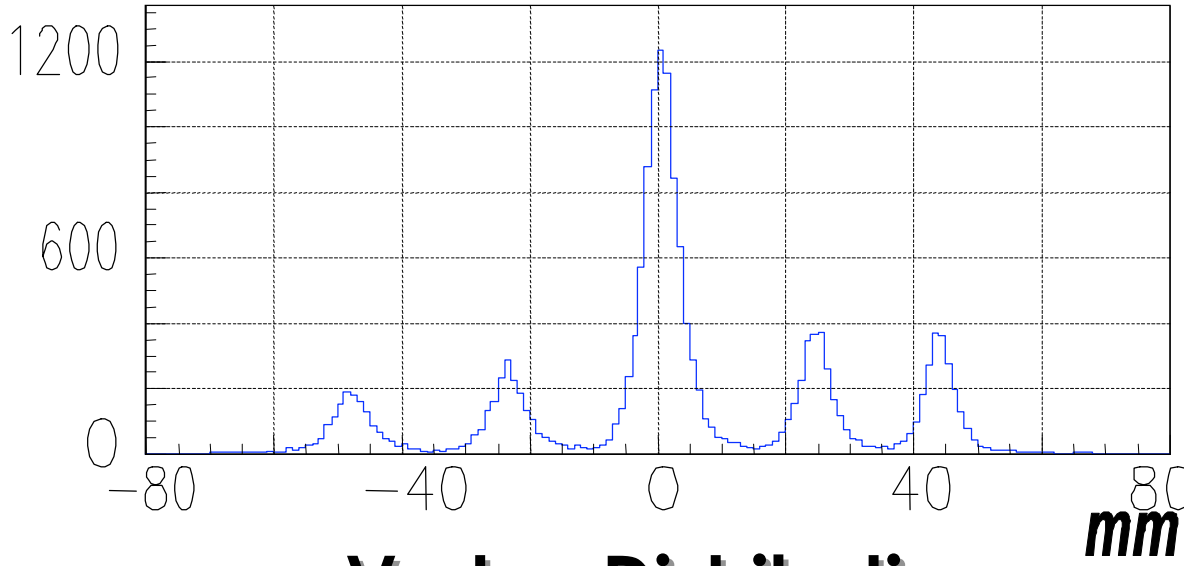


Target

- very thin target with clean and high intensity beam

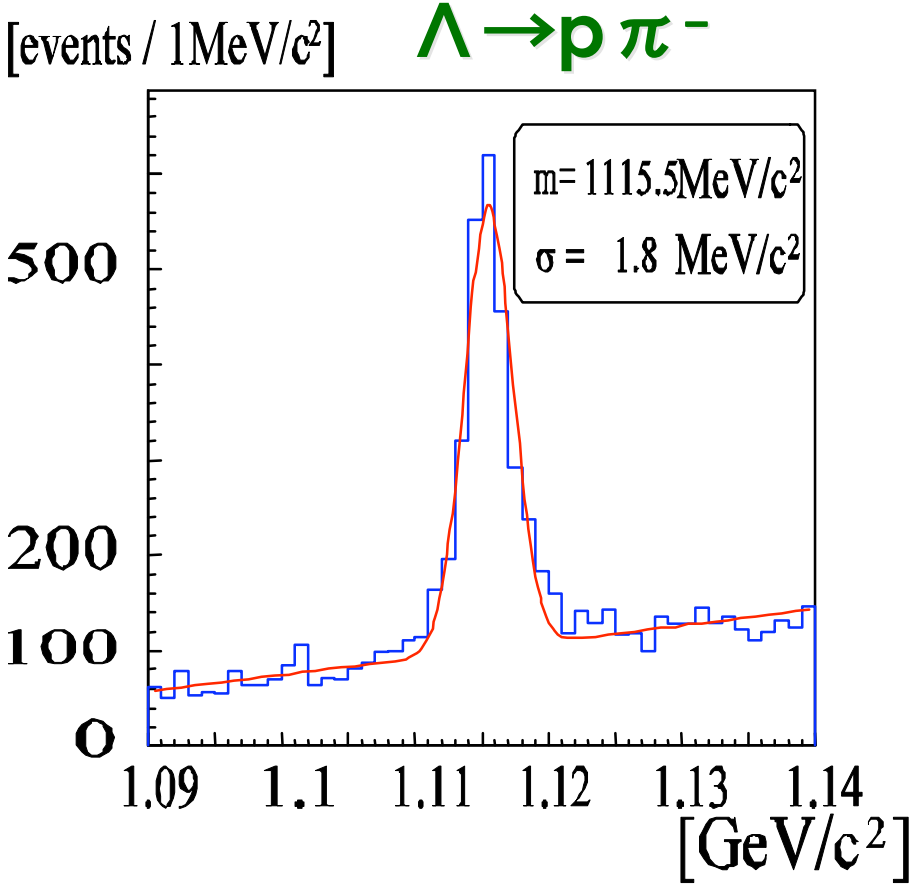


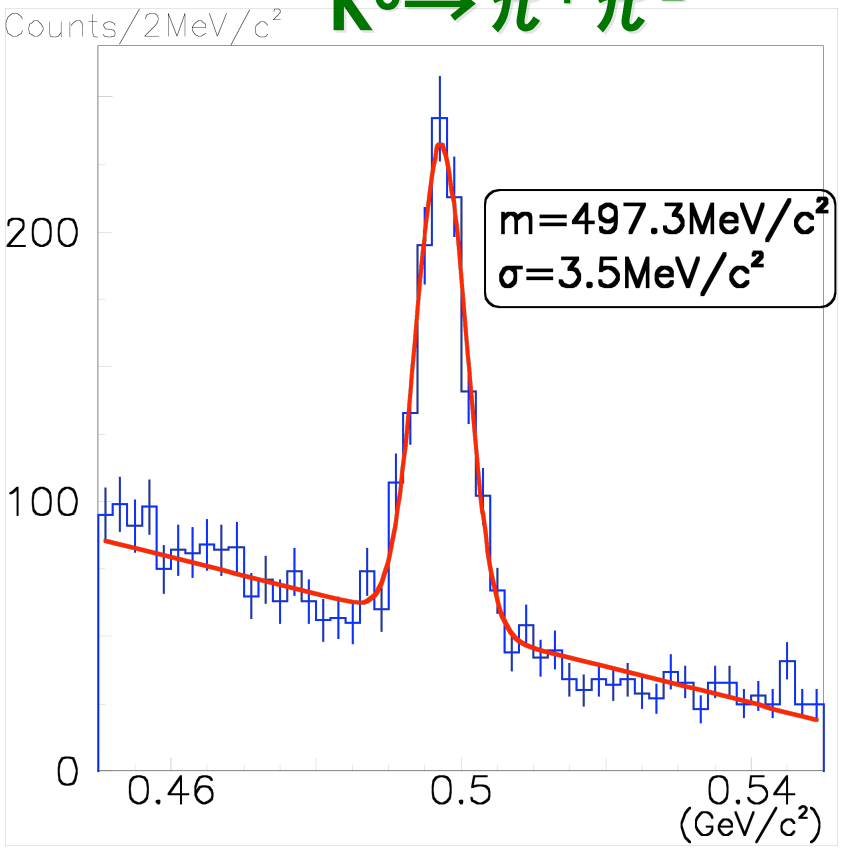
material	beam intensity(p/spill)	Interaction length(%)	radiation length(%)
C	~$1x10^9$	0.2%	0.4%
CuX4	~$1x10^9$	0.05%X4	0.5%X4



Vertex Distribution

Spectrometer Performance





M_{Λ}= 1115.5MeV/c^2 (PDG1115.7MeV/c^2)

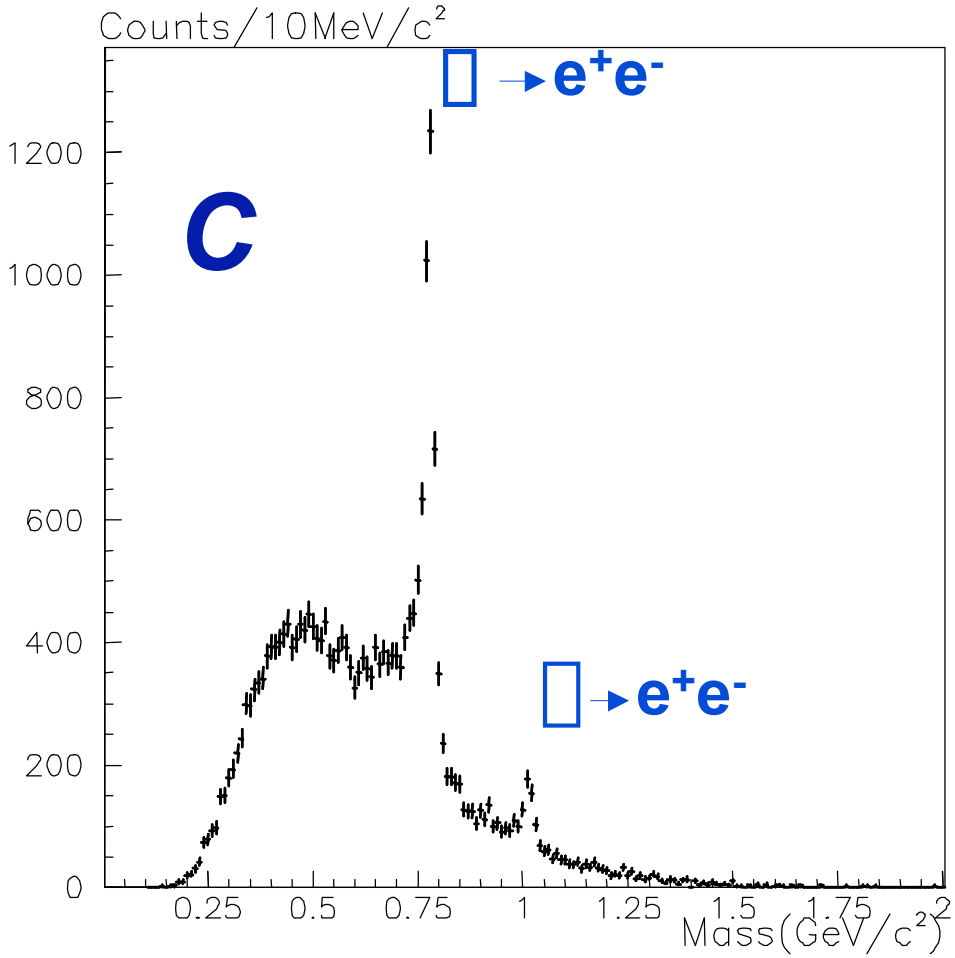
σ_{Λ} = 1.8MeV/c^2 (Sim. 1.9MeV)

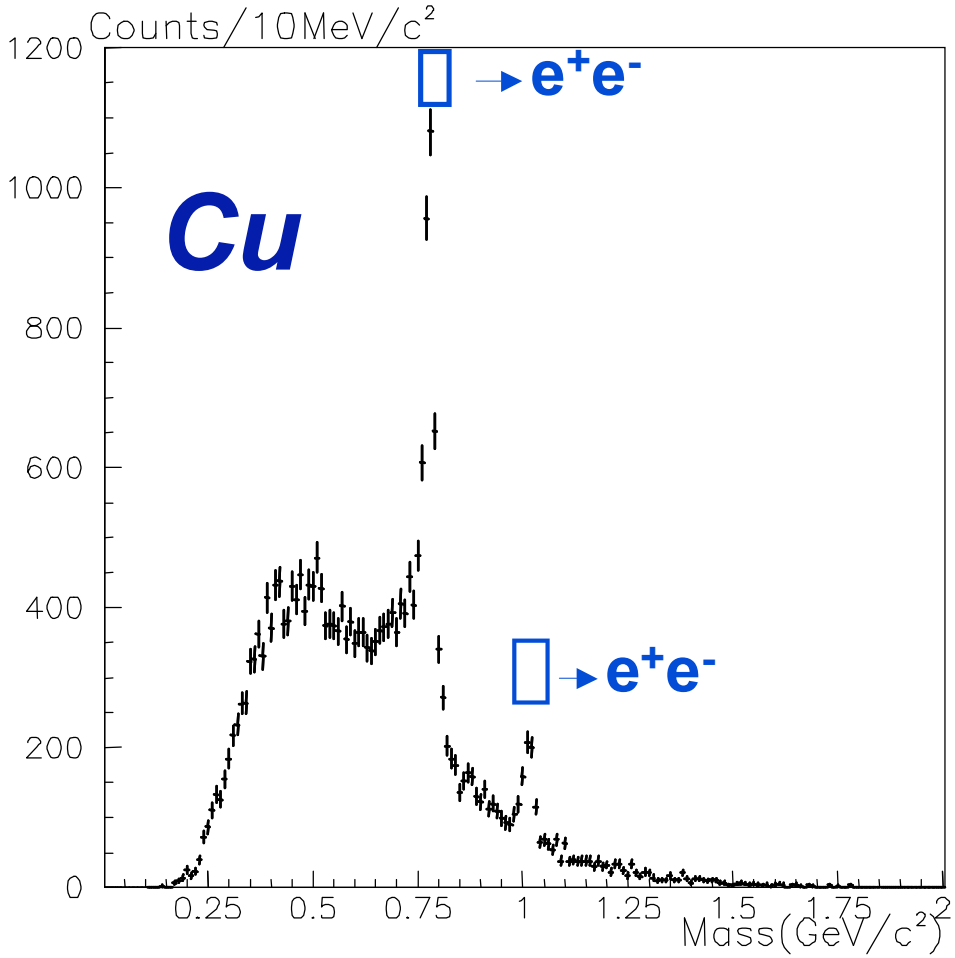
M_K= 497.6MeV/c^2 (PDG 497.7MeV/c^2)

σ_K = 3.8MeV/c^2 (Sim. 4.1MeV)

Mass and Width are well reproduced by MC.

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

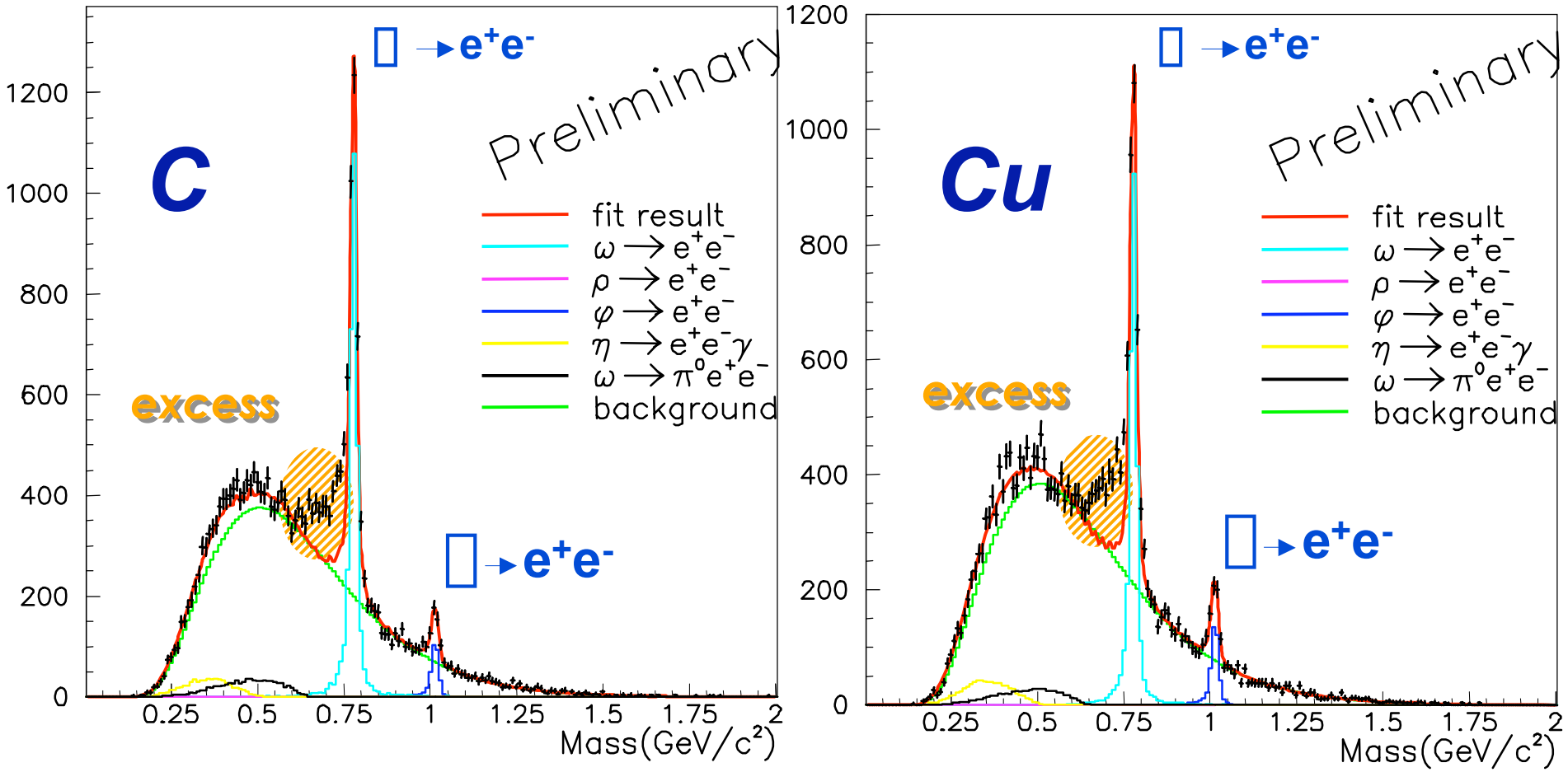




On the Fit

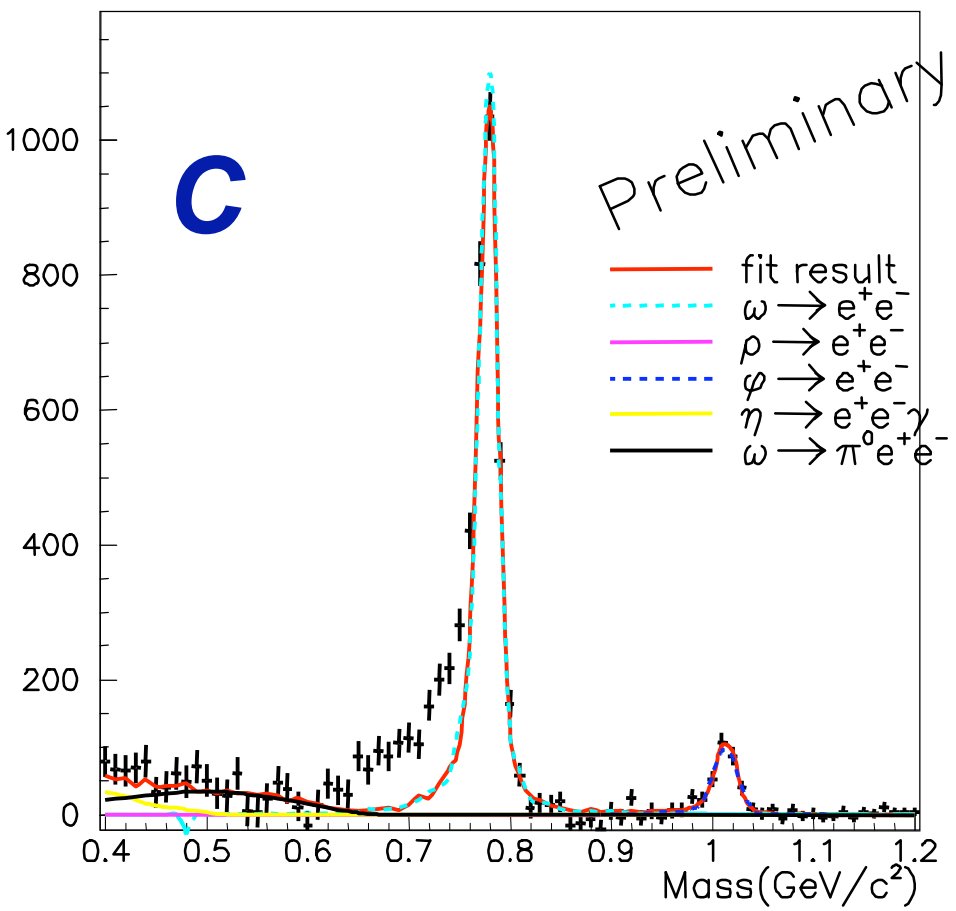
- Resonance
  - Breit-Wigner shape
  - experimental effect estimated by Geant4 simulation – energy loss, mass resolution, mass acceptance etc.
- Background
  - combinatorial background obtained by mixed events
- Relative abundances of mesons (□,□,□) and background are obtained by the fitting.

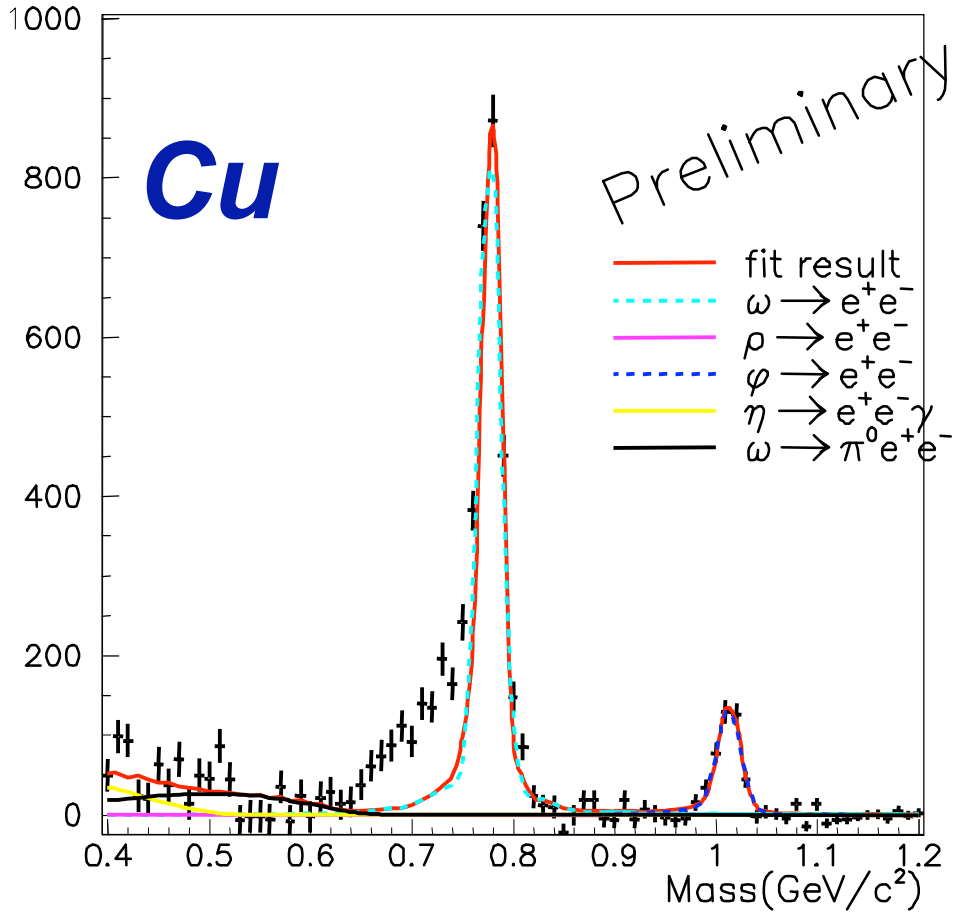
Invariant Mass Spectrum of e+e- (2002 data)



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

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



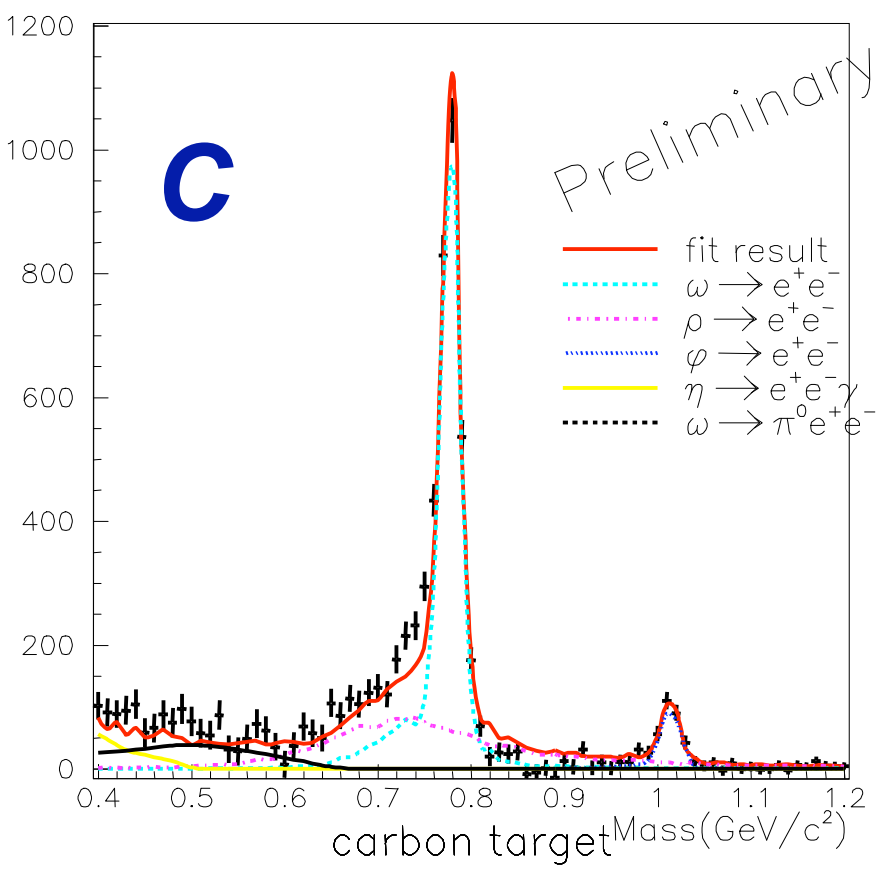


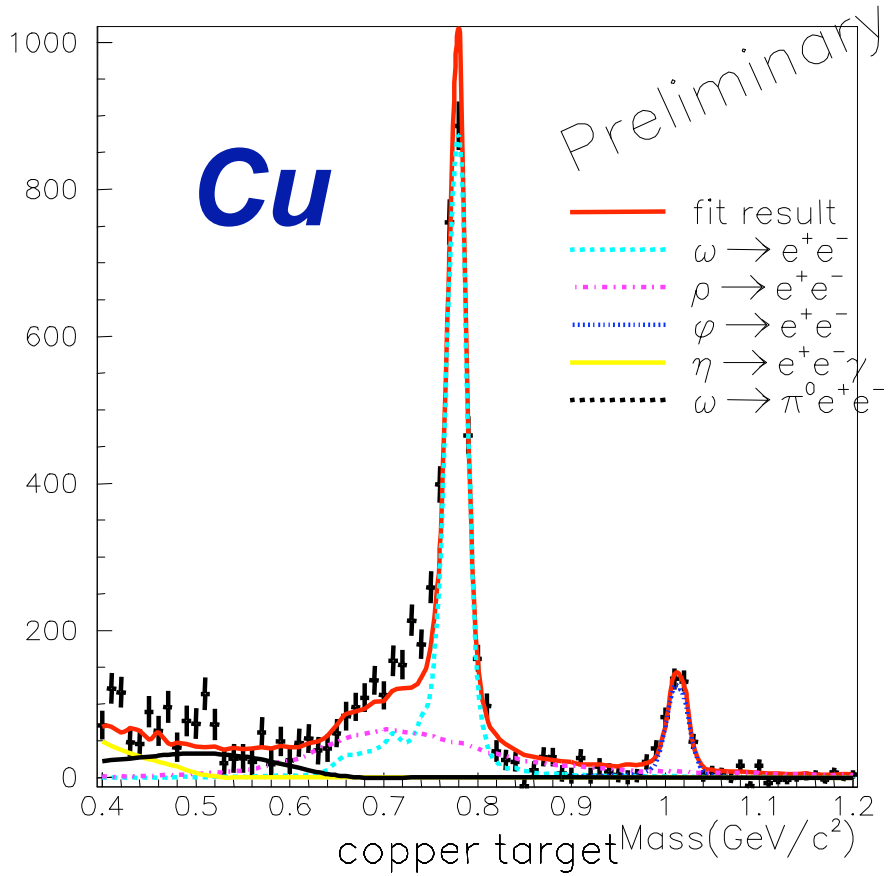
□/□ ratio is consistent with zero

0.0□0.01(stat.)□0.2(sys.) 0.0□0.05□0.5

The excess can be understood as modified □ mesons.

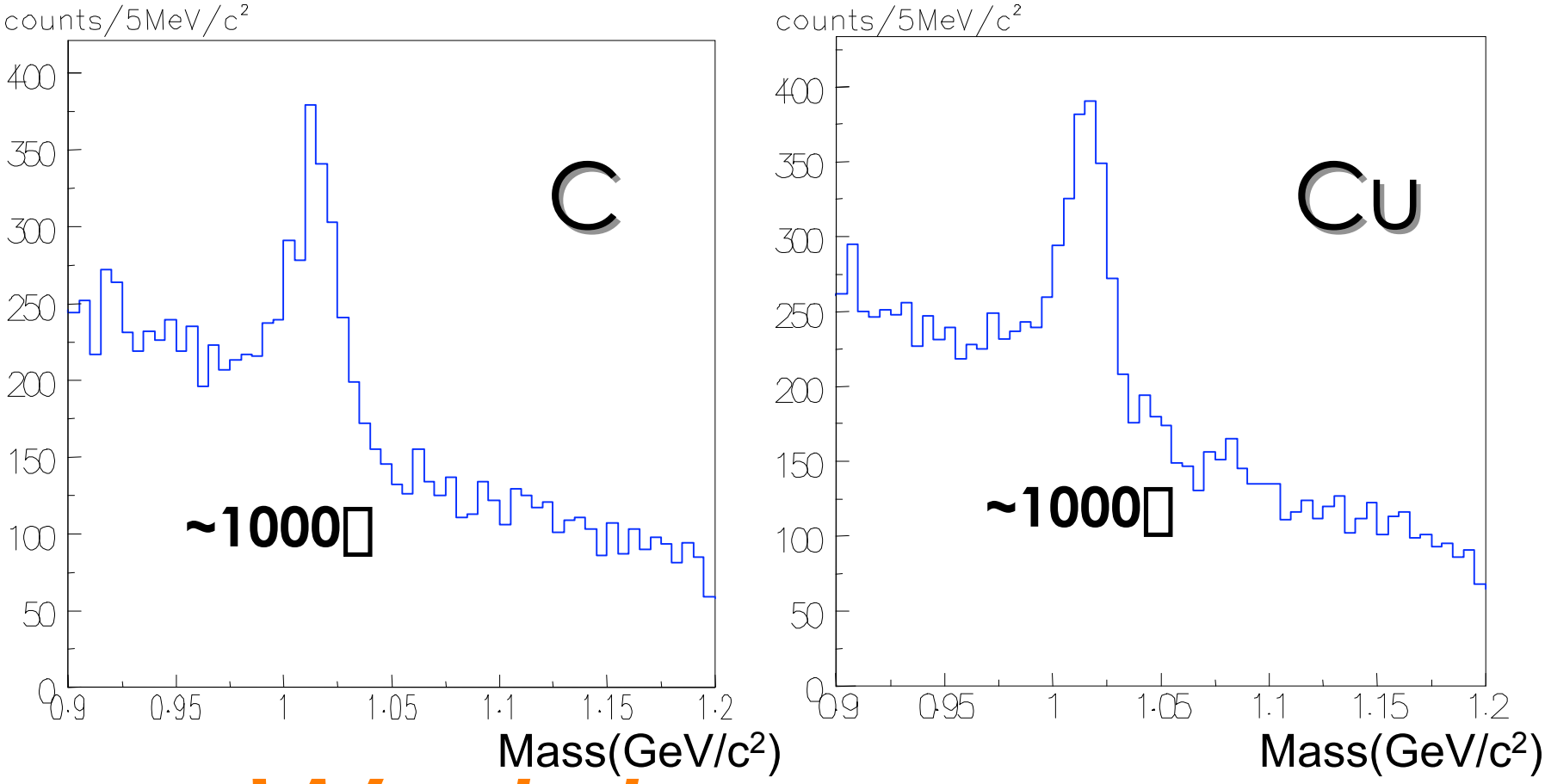
Model Calculation
With the formula : $m^*/m=1-0.16\rho/\rho_0$





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

Invariant Mass Spectrum of $\phi \rightarrow e^+e^-$

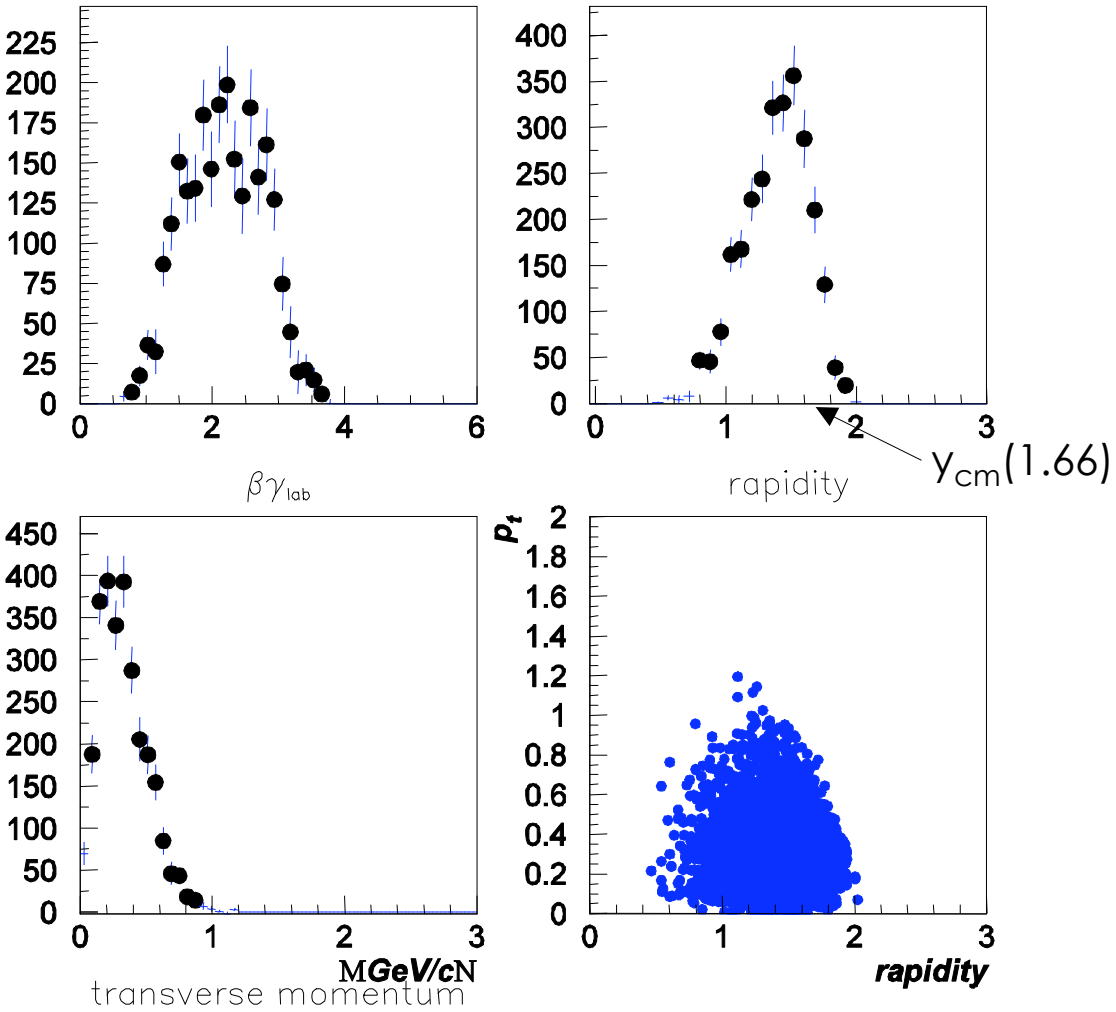


Work in progress

Summary

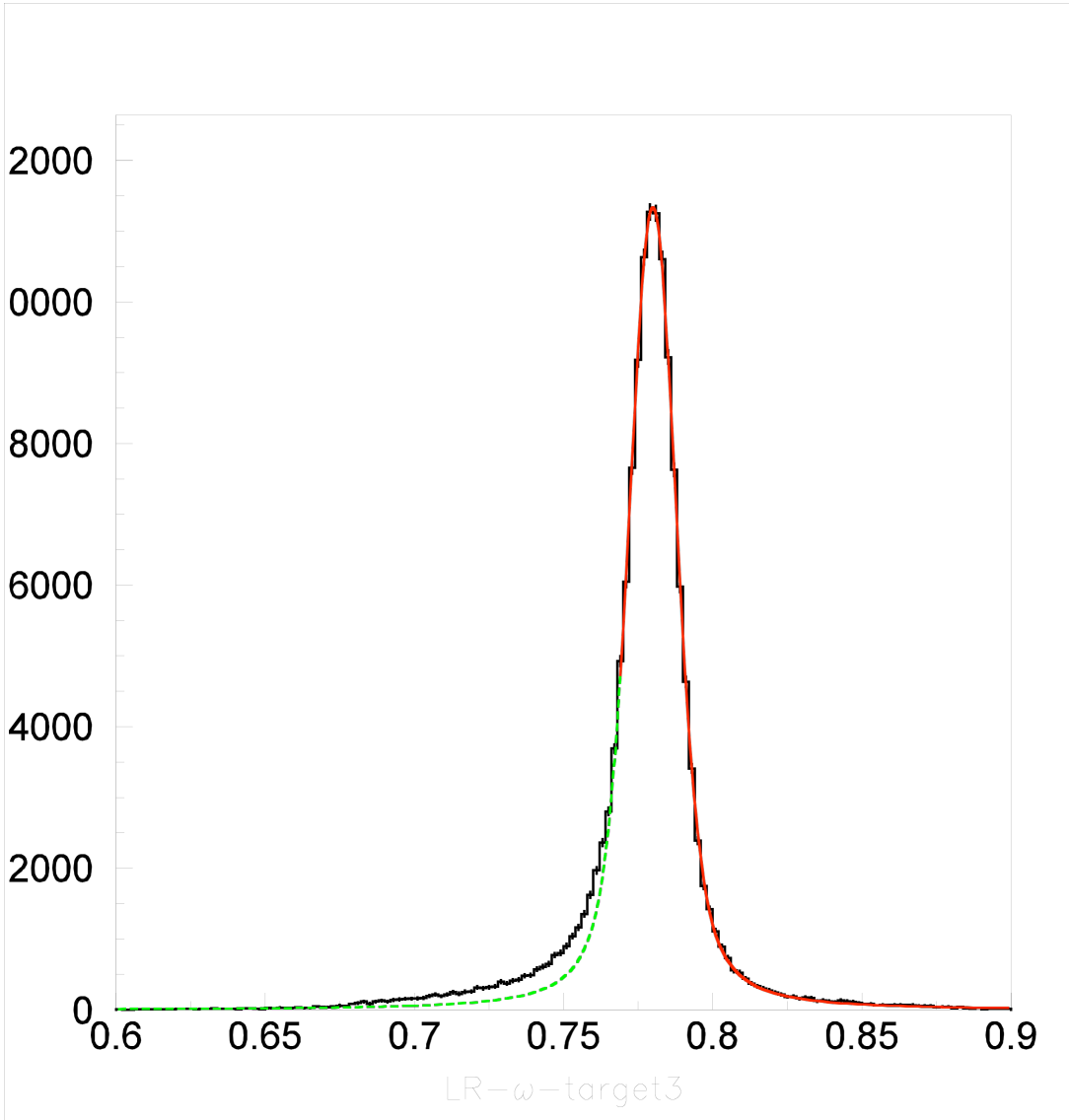
- KEK PS-E325 experiment measured e^+e^- and K^+K^- pairs to investigate invariant mass of vector mesons decaying in nuclear matter.
- In 2002 e^+e^- data, we have observed the excess over the known hadronic sources below the ϕ peak. Obtained ϕ / ω ratio indicates that this excess is mainly due to the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

kinematical distribution

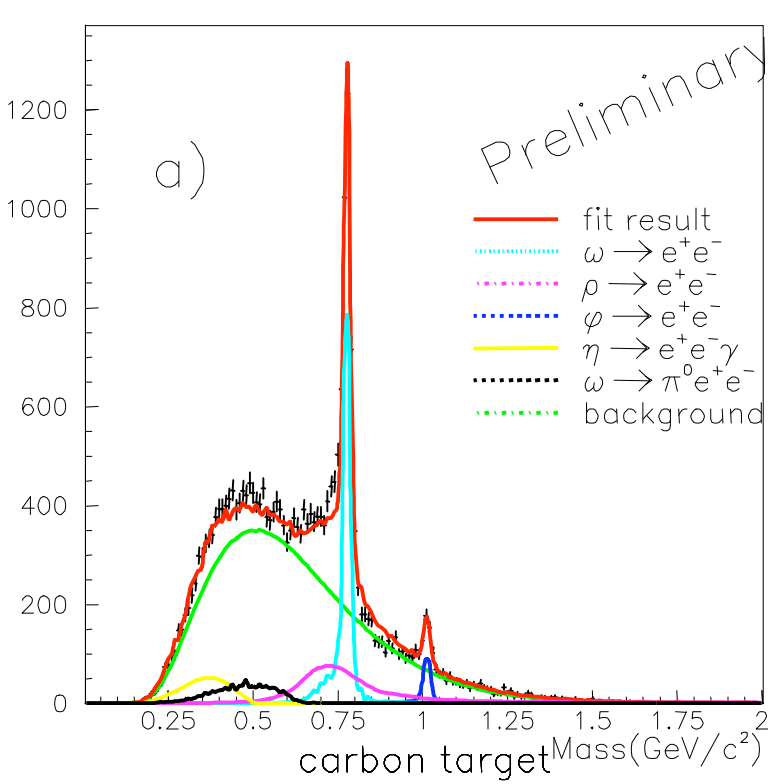


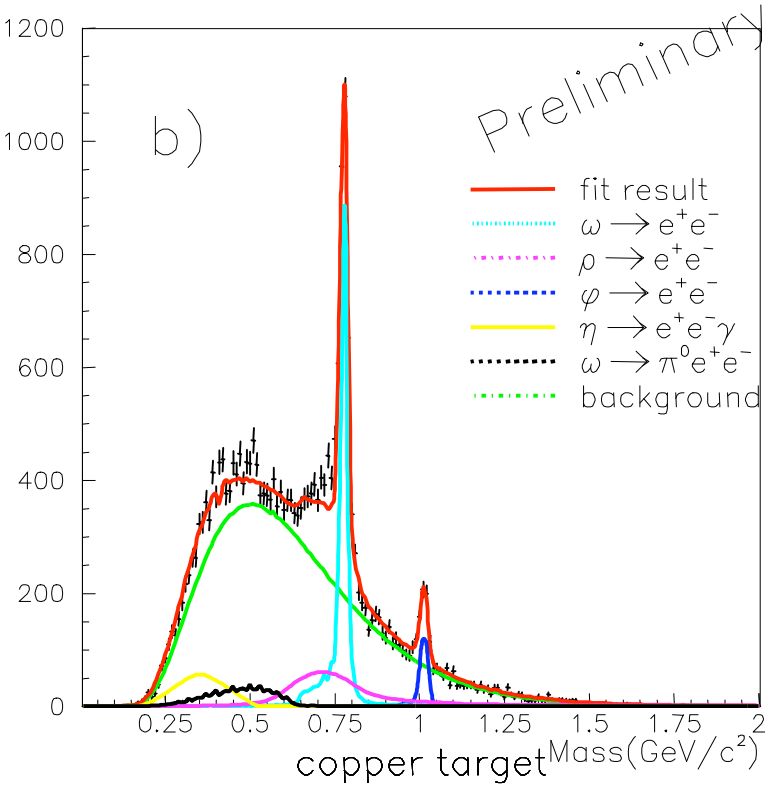
Energy Loss

- **black** line – MC
- **red** line – Breit-Wigner(gaussian convoluted) fit result
- **green** line – same as red line but excluded by fit

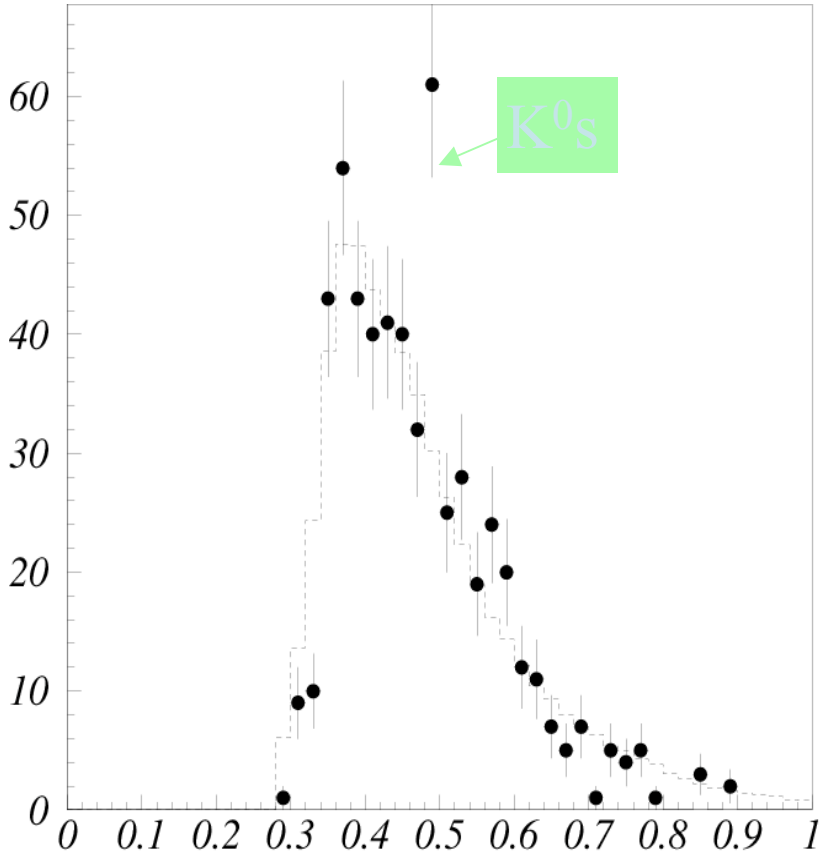


Model Calculation
With the formula : m*/m=1-0.16□/□$_0$





Combinatorial background



Spectrum of □ pair

Major background souces are

- □⁰→□□ (□→ee)
- □⁰→ ee□

□□⁺□⁻ invariant mass is well described with the mixed events.

□□⁺□⁻ correlation is only significant for K⁰s

It is reasonable to use ee mixed event for the combinatorial background