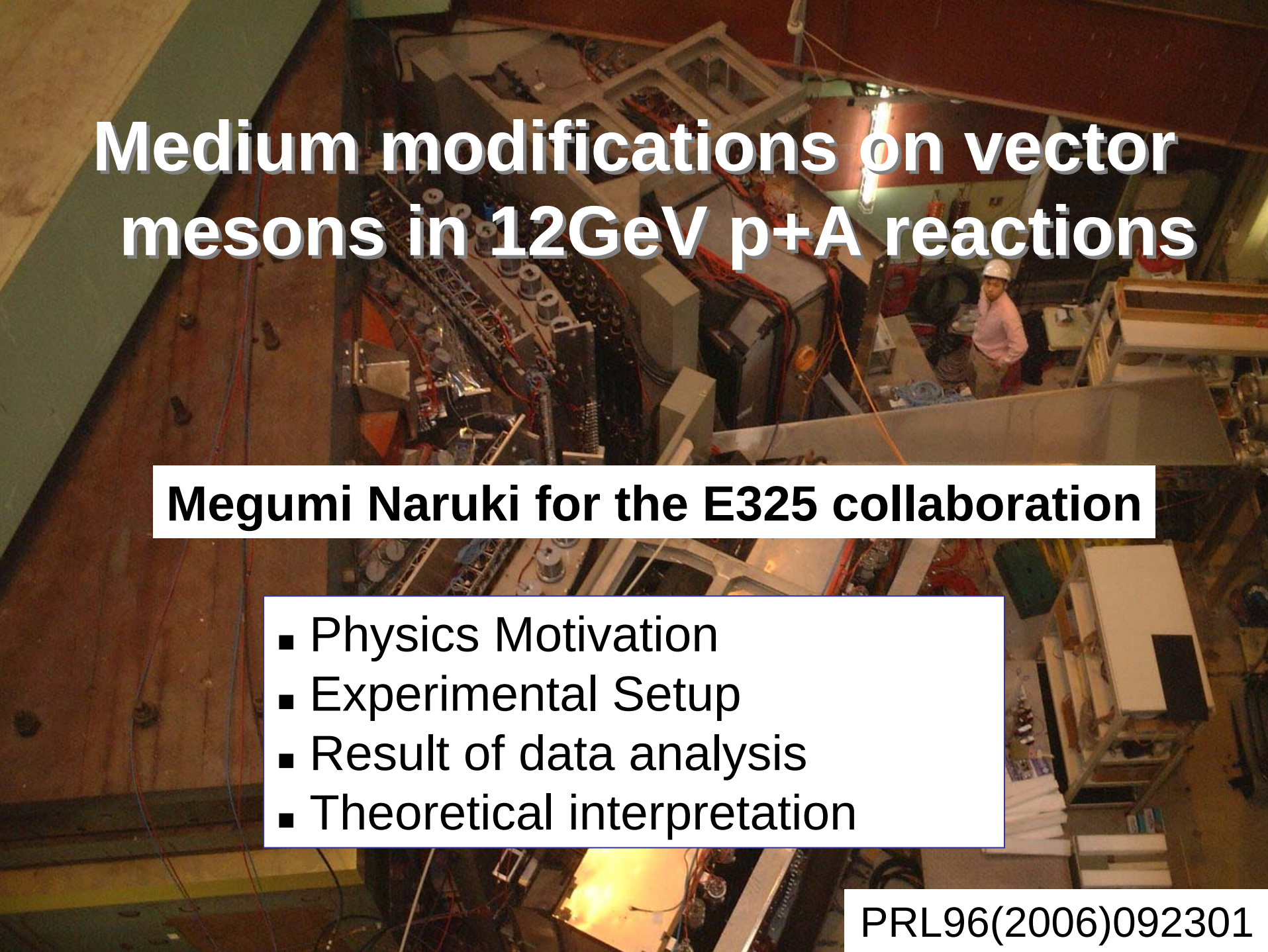


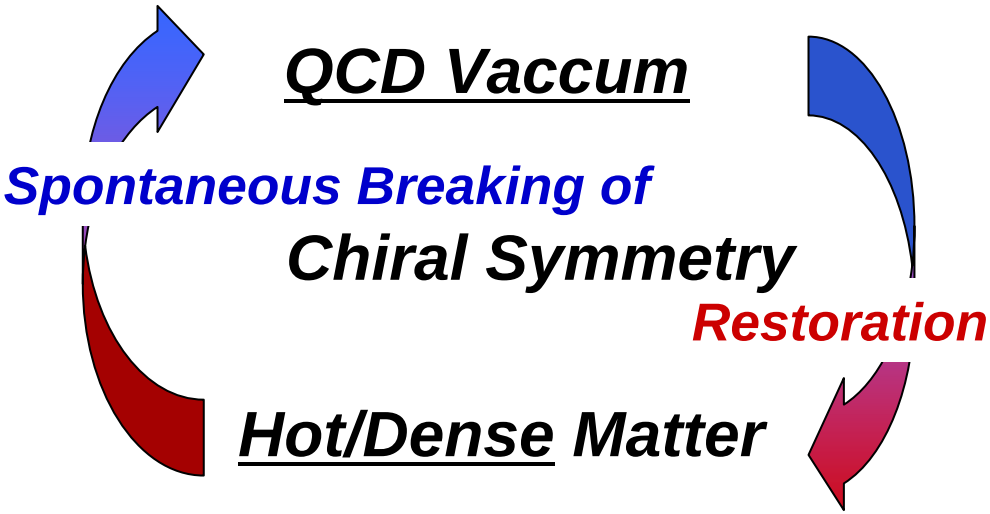
Medium modifications on vector mesons in 12GeV p+A reactions

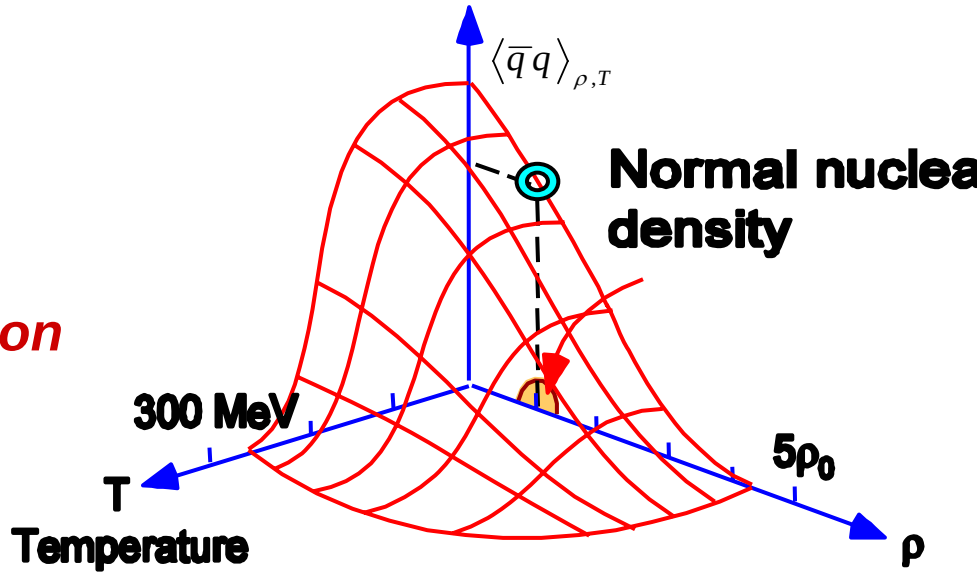
Megumi Naruki for the E325 collaboration

- Physics Motivation
- Experimental Setup
- Result of data analysis
- Theoretical interpretation

PRL96(2006)092301

Physics Motivation





Vector meson mass
at normal nuclear density

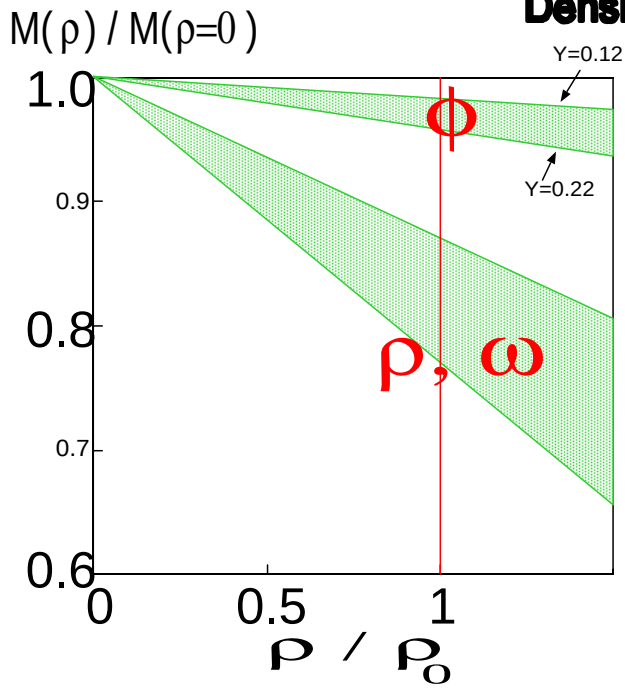
m*/m ~ 20% : Brown-Rho scaling ('91)

m*/m = 1 – k * ρ/ρ_0

(Hatsuda&Lee PRC46('92)R34)

ρ/ω : **Δm = 130 MeV**

ϕ : **Δm = 20~40 MeV**



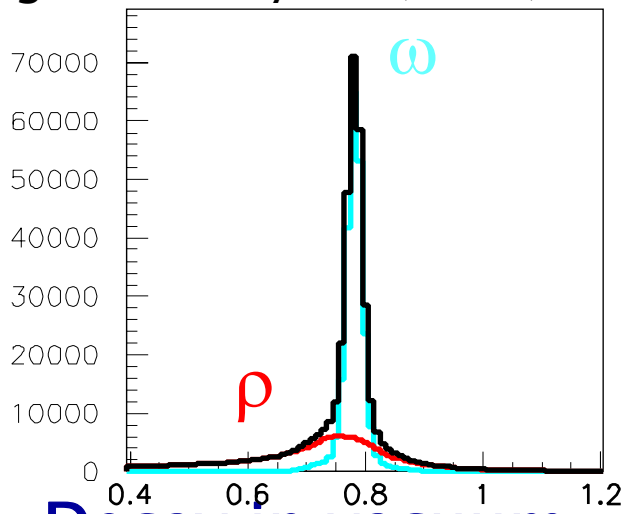
E325 experiment

observed Invariant Mass of e^+e^-, K^+K^- in 12GeV p + A → ρ, ω, ϕ + X reactions

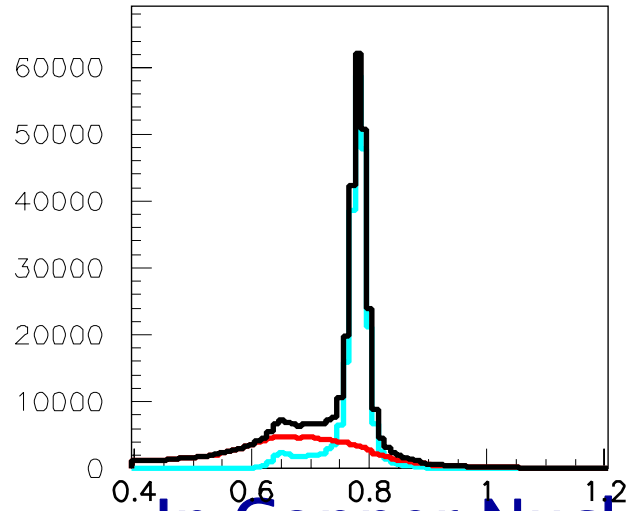
first dilepton measurement at the normal nuclear density

Expected Invariant Mass distribution of ρ and ω

mass modified by the formula $m^*/m = 1 - 0.16 * \rho/\rho_0$
Prog.Theor.Phys.95(1996)1009



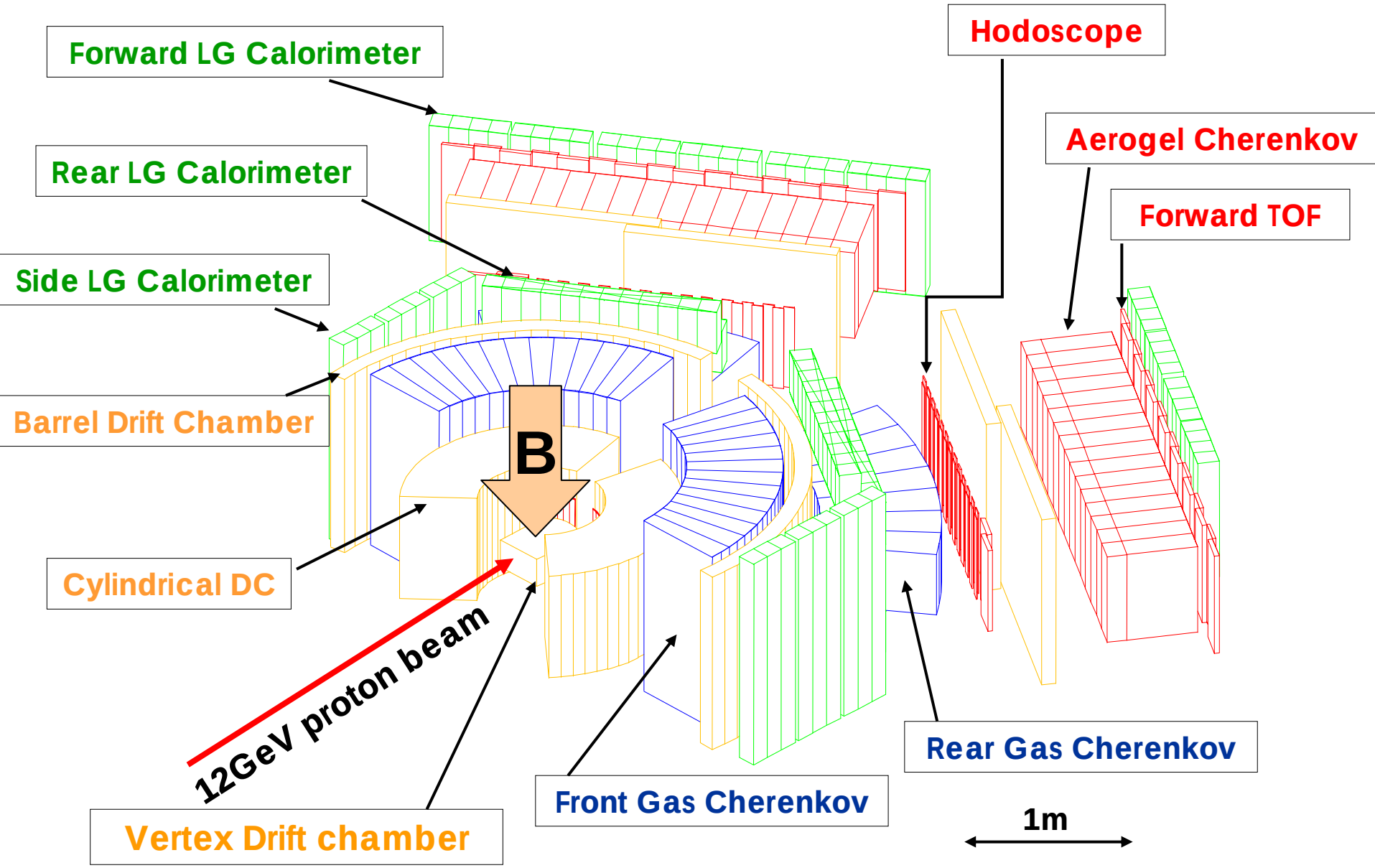
Decay in vacuum



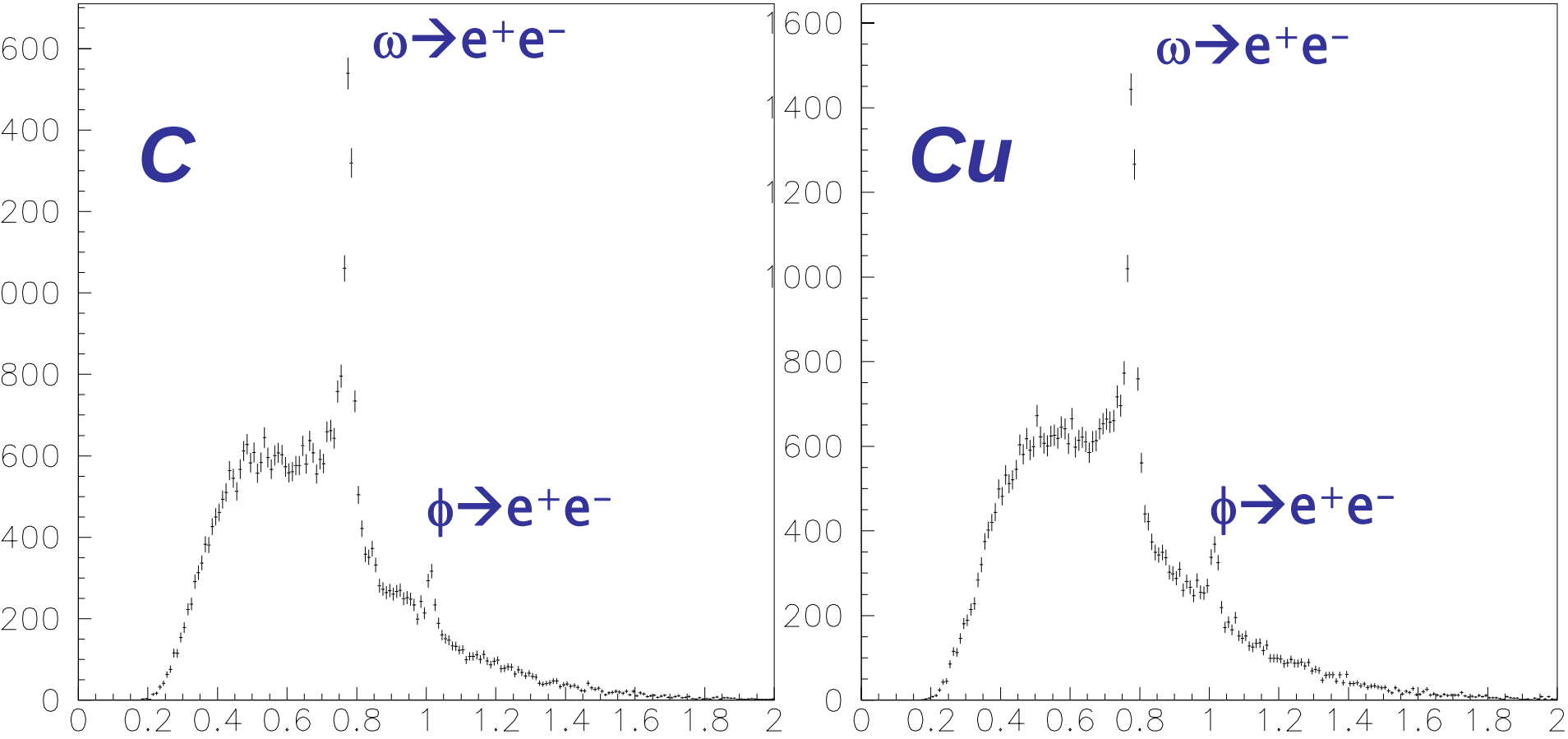
In Copper Nuclei

Slowly moving ρ ω ϕ (p_{lab} ~ 2GeV/c)
→ Large Acceptance Spectrometer

Detector Setup



Invariant Mass Spectrum of e^+e^-



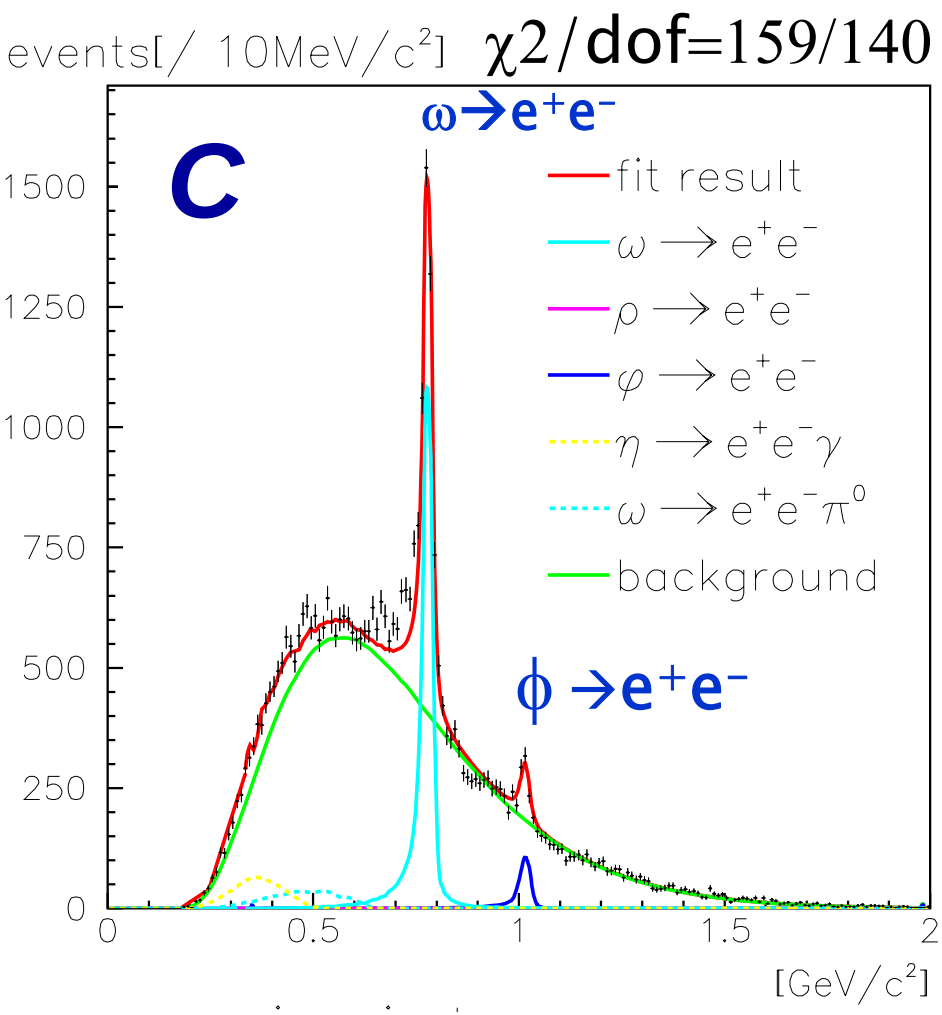
we examine how well the data is reproduced with known hadronic sources & combinatorial background

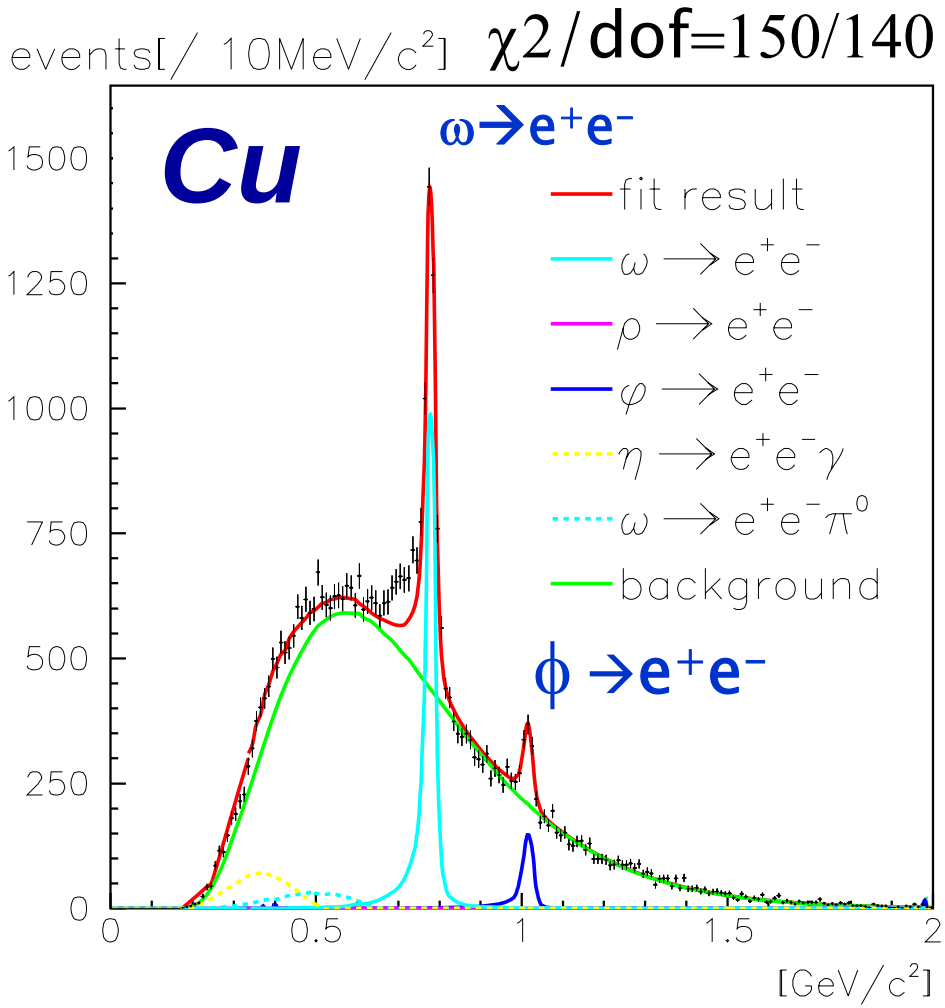
On the Fit

- **resonance**
  - relativistic Breit-Wigner shape
  - generator : nuclear cascade code JAM gives momentum
  - experimental effect estimated through Geant4 simulation – energy loss including Bremsstrahlung, multiple scattering, tracking performance and detector acceptance.
- **background**
  - combinatorial background obtained by mixed events.
- **fit parameters**
  - relative abundances of mesons (ρ,ω,ϕ) , η Dalitz and background are obtained by the fitting.

Invariant Mass Spectrum of e^+e^-

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

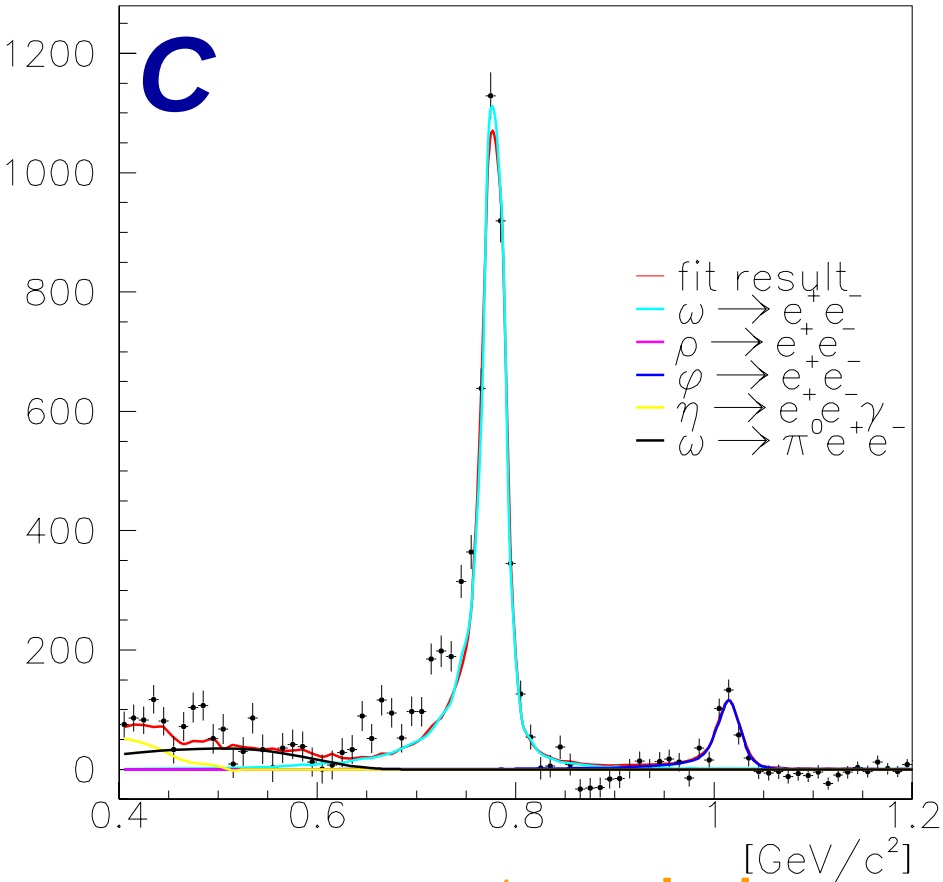


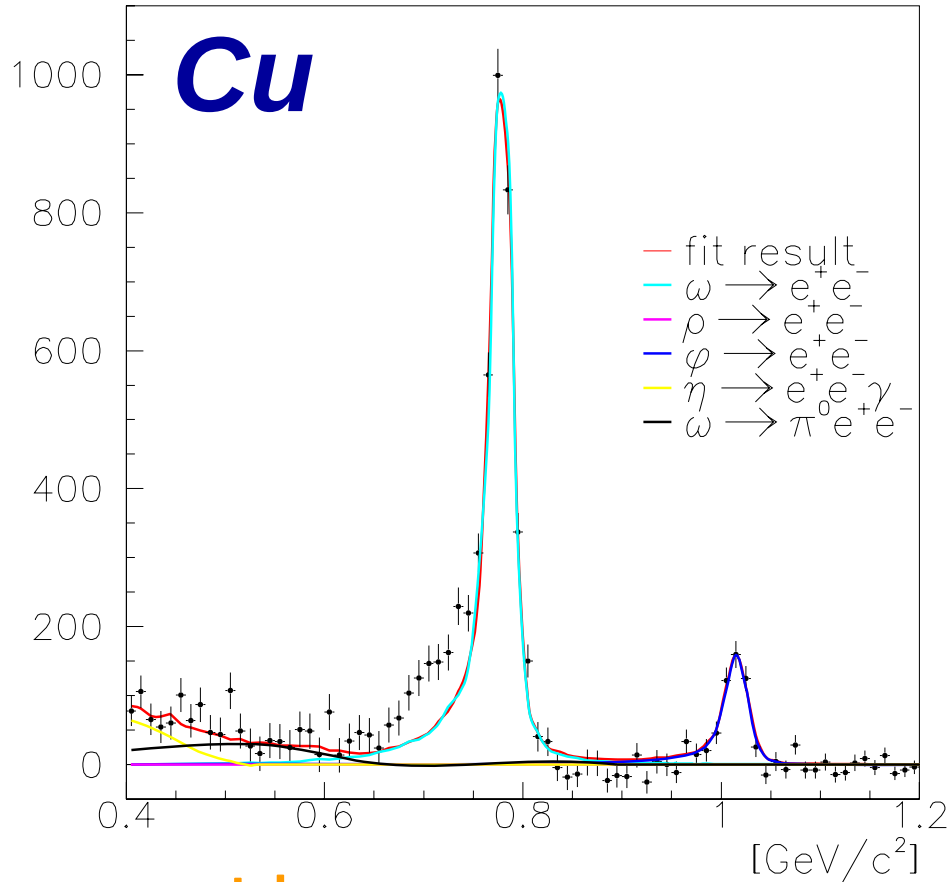


the excess over the known hadronic sources on the low mass side of ω peak has been observed.

Invariant Mass Spectrum of e^+e^- (BG subtracted)

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





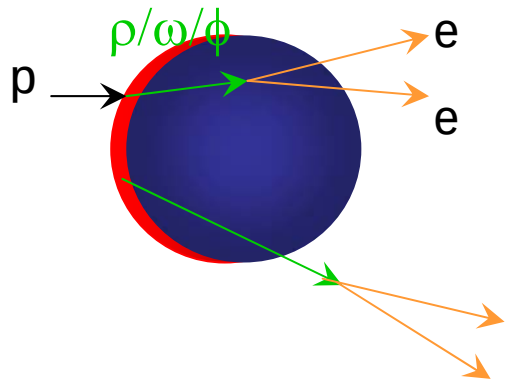
ρ/ω ratio is consistent with zero

$N\rho/N\omega = 0.0 \pm 0.03(\text{stat.}) \pm 0.09(\text{sys.})$ $0.0 \pm 0.04(\text{stat.}) \pm 0.21(\text{sys.})$

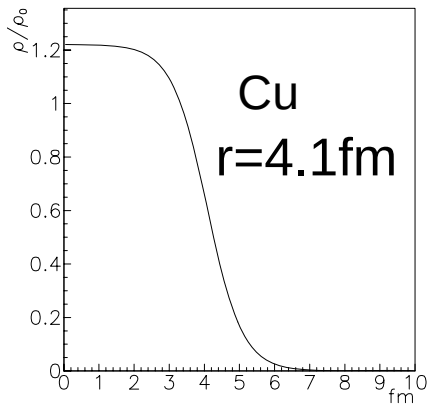
It is pretty much surprising because the ρ/ω is known to be unity in pp interactions (Blobel et. al, PLB48('74)73)

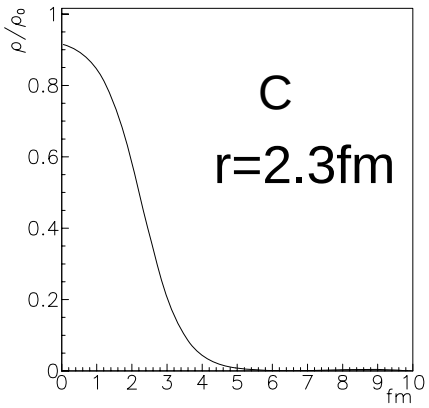
Toy Model Calculation

- pole mass: $\frac{m^*}{m} = 1 - k\frac{\rho}{\rho_0}$ (Hatsuda-Lee formula)
- generated at surface of incident hemisphere of target nucleus
  - $\alpha_\omega = 0.71 \pm 0.02$
    ($\alpha_\phi = 0.94 \pm 0.05$) [nucl-ex/0603013]
  - decay inside nucleus:



	C	Cu
ρ	52%	66%
ω	5%	10%





- density distribution - Woods-Saxon
- mass spectrum: relativistic Breit-Wigner Shape
- no width modification

Confidence ellipsoids for k and ρ/ω shift model : $m^*/m = 1 - k\,\rho/\rho_0$

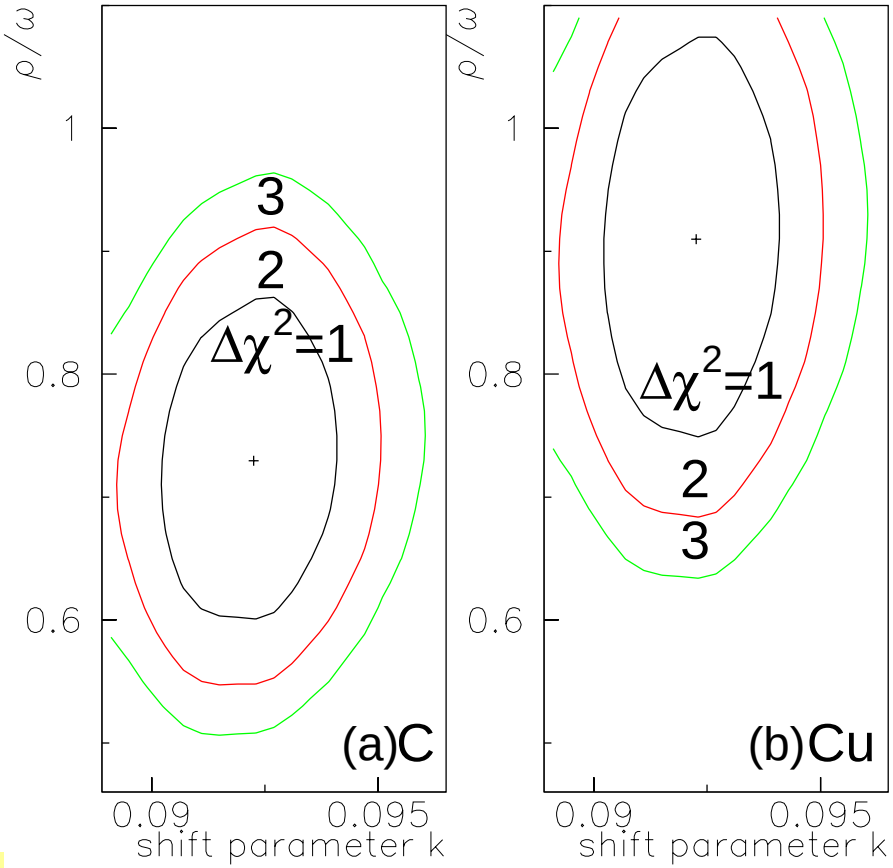
- C and Cu data were simultaneously fitted.
- free paramters
  - production ratio ρ/ω
  - shift parameter k
- Best-Fit values are

$k = 9.2 \pm 0.2\%$

$\rho/\omega = 0.7 \pm 0.1$ (C)

0.9 ± 0.2 (Cu)

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



Fit Results of Model Calculation

$m^*/m = 1 - 0.092\ \rho/\rho_0$

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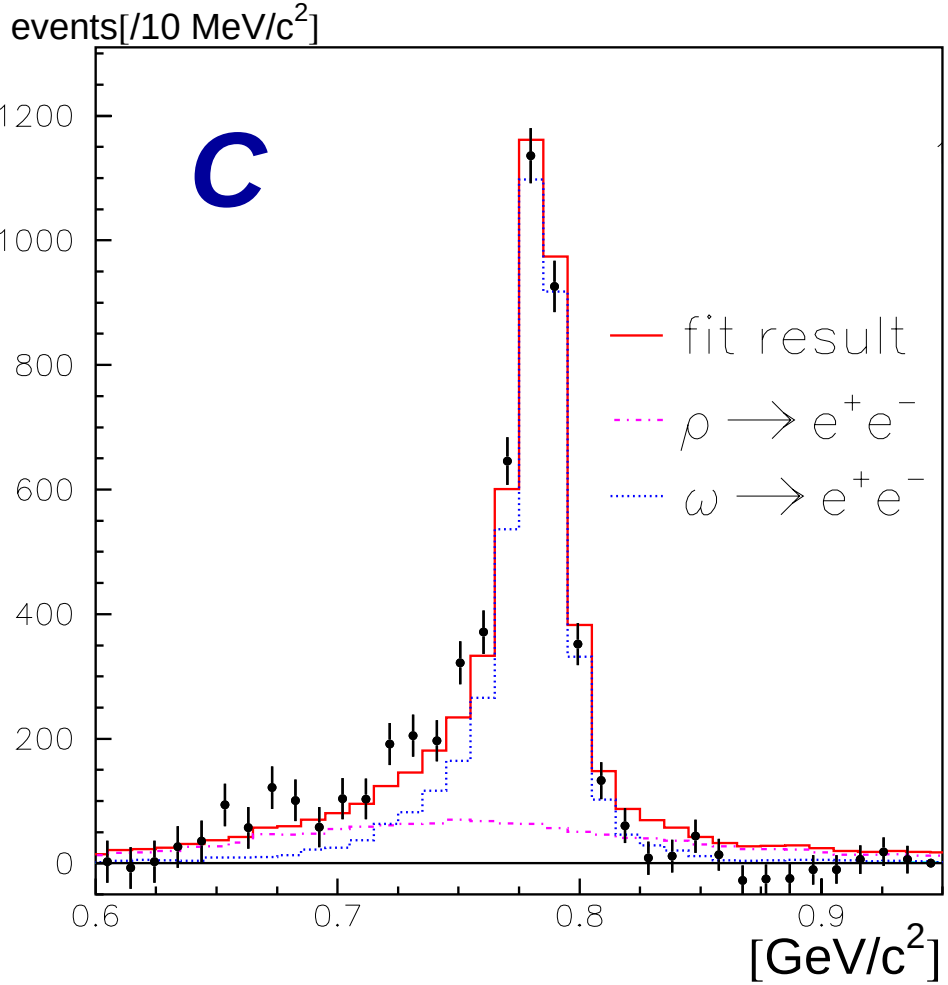
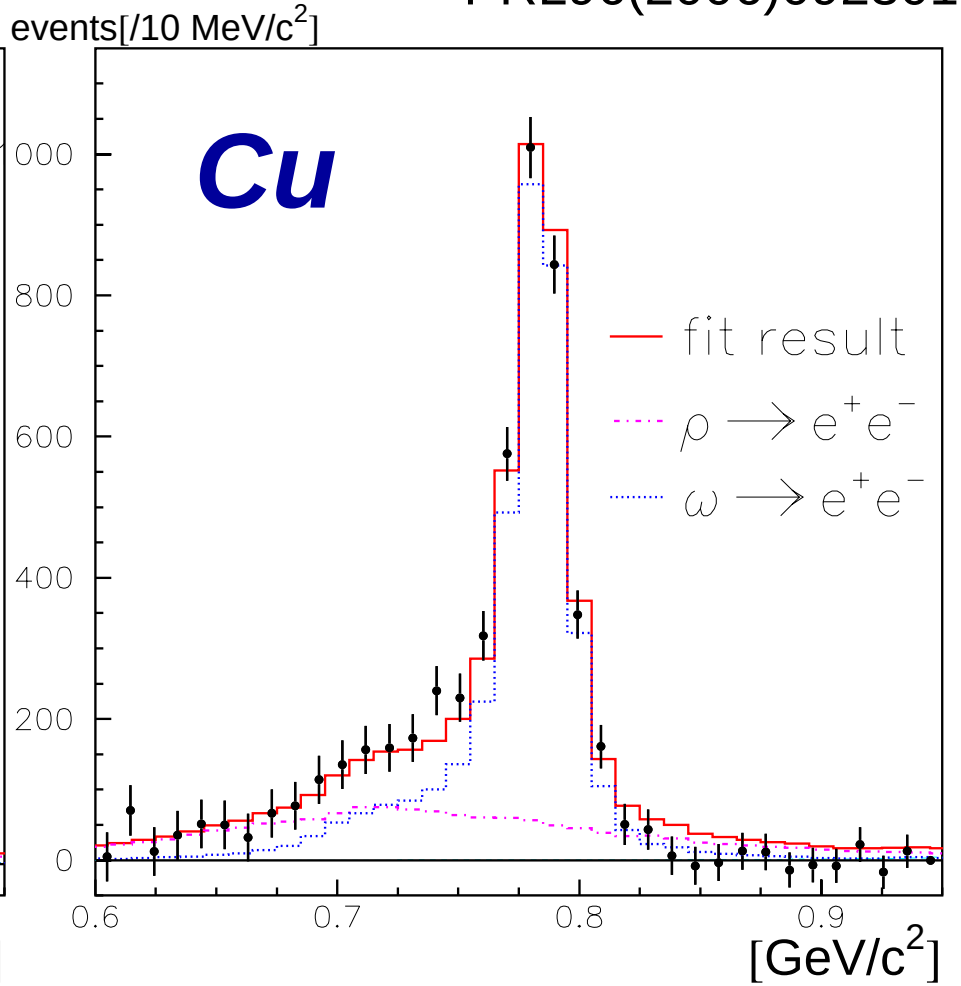
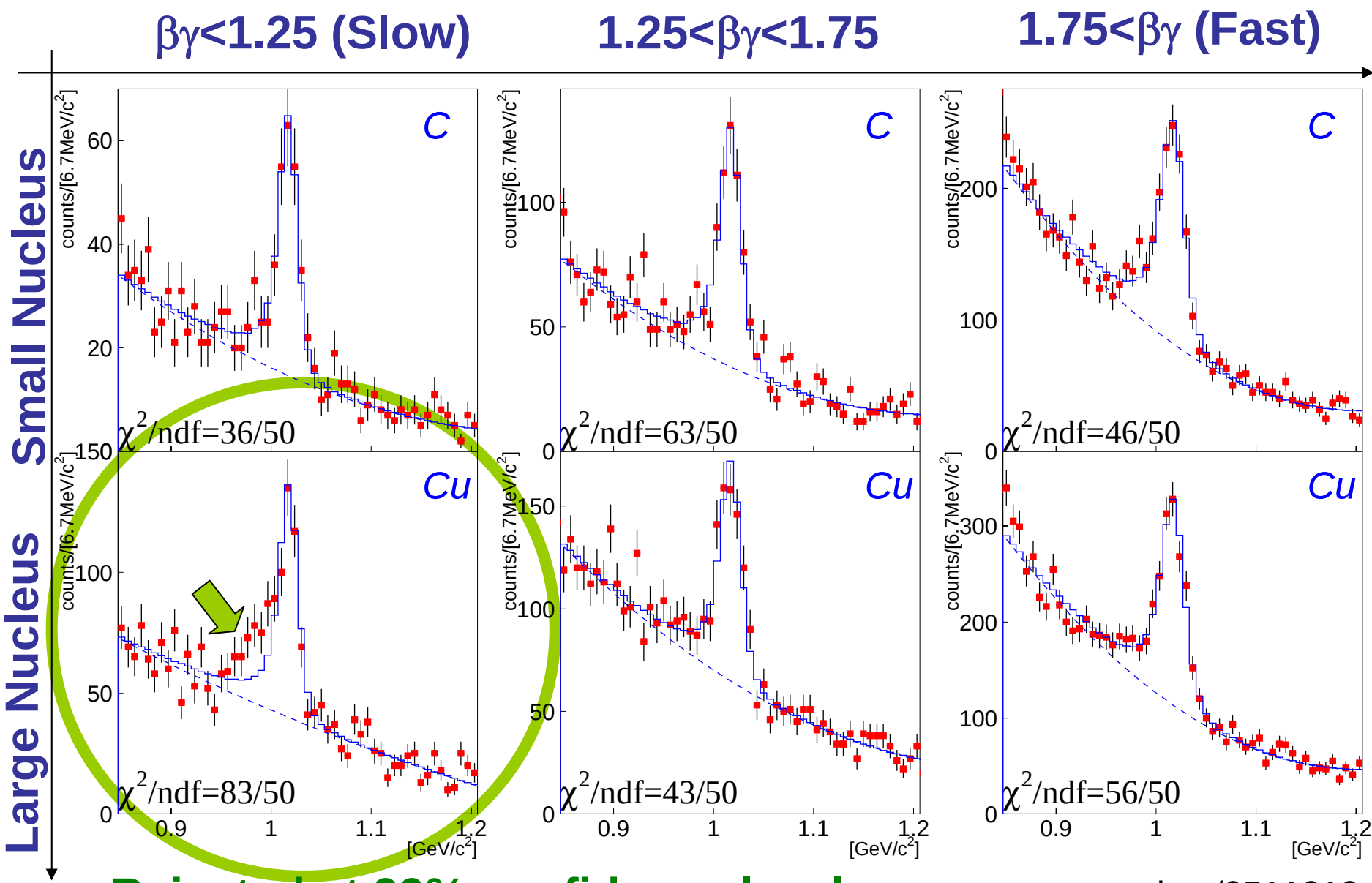




the excesses for C and Cu are well reproduced by the model including the mass modification.

Invariant spectra of $\phi \rightarrow e^+e^-$



Rejected at 99% confidence level

nucl-ex/0511019

Contours for k_1 and k_2 of $\phi \rightarrow e^+e^-$

MC including in-medium mass modificaton of ϕ

Pole Mass Shift

$M(\rho)/M(0) = 1 - k_1 (\rho/\rho_0)$

Width Broadening

$\Gamma(\rho) / \Gamma(0) = 1 + k_2 (\rho/\rho_0)$

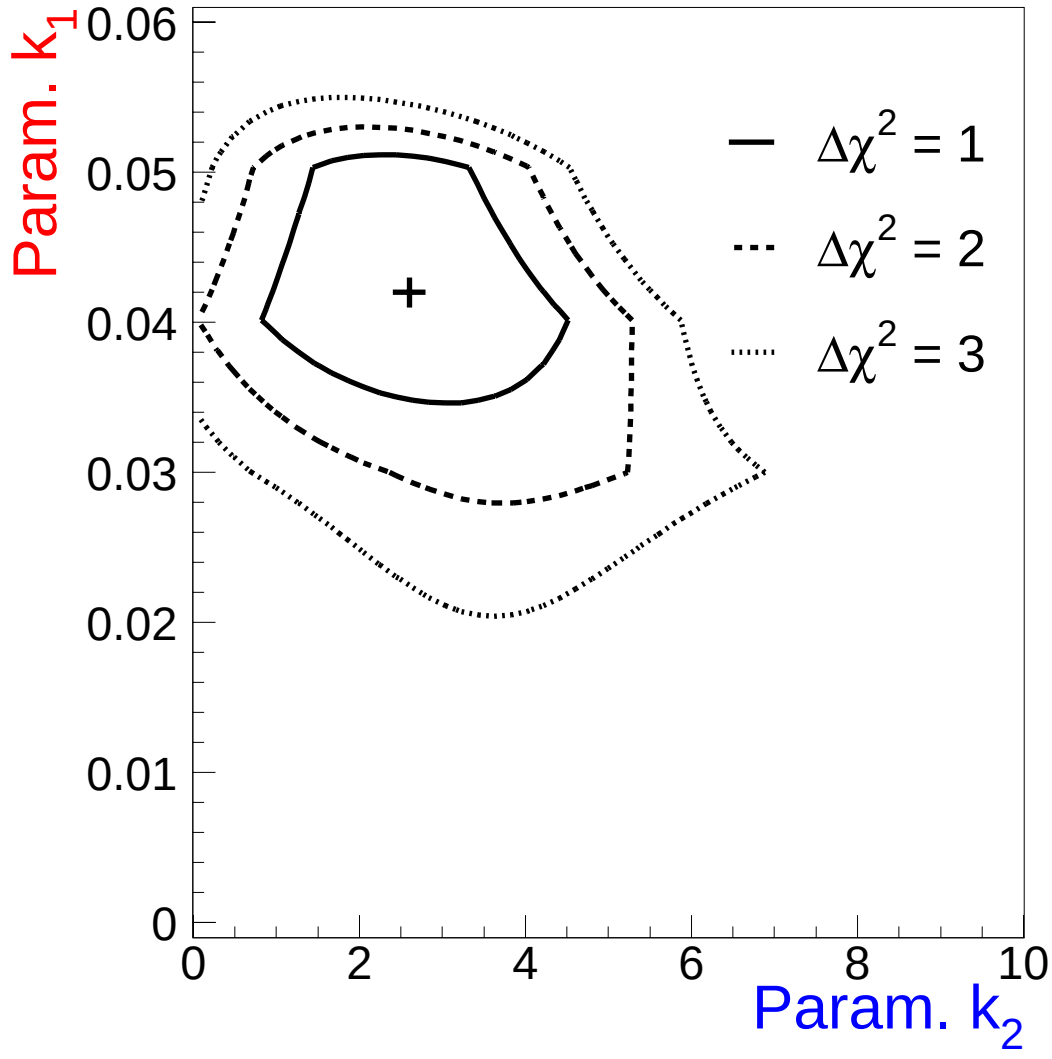
ϕ mesons are generated uniformly in target nucleus

We fitted the observed mass spectra with modified MC shape in all $\beta\gamma$ region

Best Fit Value:

$k_1 = 0.042 \pm 0.008$

$k_2 = 2.6 \pm 1.9$



Summary

- 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.
- We also observed the excess at low-mass side of ϕ, only at the low $\beta\gamma$ region of Cu data.
- The data was well reproduced by the model calculation, in which;
  - ✓ the mass of ρ/ω decreases by 9% at ρ_0 ,
  - ✓ for ϕ , the mass decreases by 4% and the width increases by a factor of 4 at ρ_0.