Studying the ϕ meson in nuclear matter by simulating low energy pA reactions

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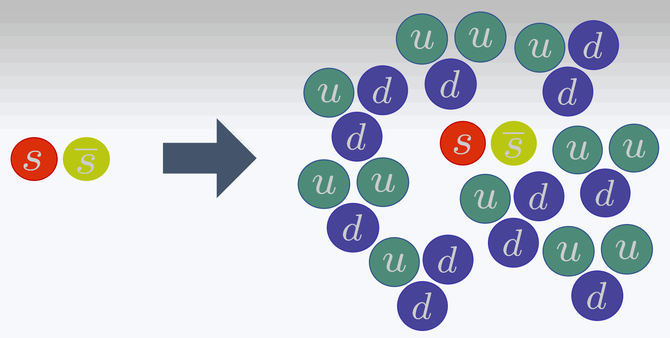
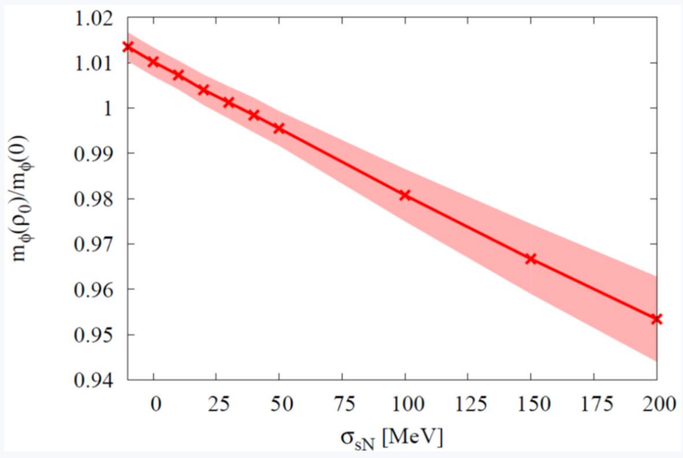
Introduction, Motivation



The ϕ meson in nuclear matter

Information about the strange quark condensate at finite density:

$$\langle \bar{s}s \rangle_\rho = \langle \bar{s}s \rangle_0 + \langle N|\bar{s}s|N\rangle \rho + \dots$$
$$= \langle \bar{s}s \rangle_0 + \frac{\sigma_{sN}}{m_s}\rho + \dots$$



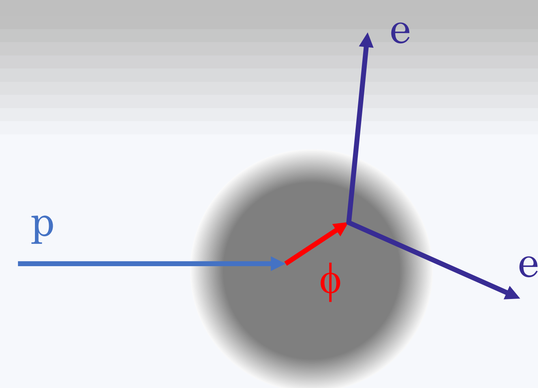
P. Gubler and K. Ohtani, Phys. Rev. D **90**, 094002 (2014).

$$\sigma_{sN} = m_s \langle N|\bar{s}s|N\rangle$$

strangeness content of the nucleon

important parameter for dark matter searches

Experimental measurement



Dileptons from pA reactions

Dilepton spectrum of the KEK E325 experiment

Spectra of p + Cu reactions with 12 GeV protons

Conclusions:

$$\frac{m_\phi(\rho)}{m_\phi(0)} = 1 - k_1 \frac{\rho}{\rho_0}$$

with $k_1 = 0.034 \pm 0.007$

$$\frac{\Gamma_\phi(\rho)}{\Gamma_\phi(0)} = 1 + k_2 \frac{\rho}{\rho_0}$$

with $k_2 = 2.6 \pm 1.5$

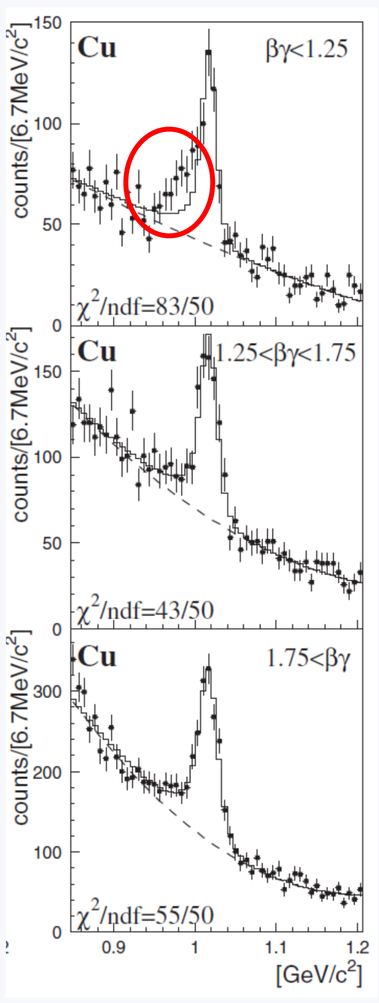
This measurement will be repeated at the E16 experiment at J-PARC with 100x increased statistics!

R. Muto et al. (E325 Collaboration), Phys. Rev. Lett. **98**, 042501 (2007).

slow ϕs

intermediate ϕs

fast ϕs



Our simulation: pA reactions in a transport approach (PHSD)

Our tool: Parton-Hadron-String-Dynamics (PHSD)

- Covariant dynamical transport approach
- Off-shell transport equations
- Any vector meson spectral function (incl. medium dependence) can be incorporated in the numerical simulation

Our model of the spectral function

A relativistic Breit-Wigner with density dependent mass and width

$$A_V(M,\rho_N) = C\frac{2}{\pi}\frac{M^2\Gamma_V^*(M,\rho_N)}{(M^2 - M_0^{*2}(\rho_N))^2 + M^2\Gamma_V^{*2}(M,\rho_N)}$$

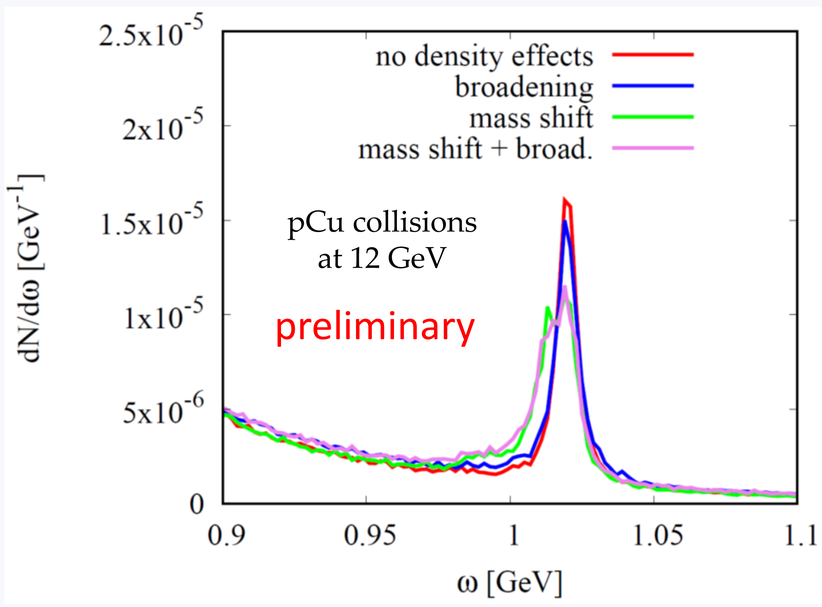
with
$$\begin{cases} M_0^*(\rho_N) = M_0\left(1 - \alpha\frac{\rho_N}{\rho_0}\right) \\ \Gamma_V^*(M,\rho_N) = \Gamma_V(M) + \alpha_{\text{coll}}\frac{\rho_N}{\rho_0} \end{cases}$$

four scenarios:

	α^ϕ	$\alpha^\phi_{\text{coll}}$ [MeV]
no density dependence	0	0
broadening	0	11
mass shift	0.034	0
mass shift + broadening	0.034	11

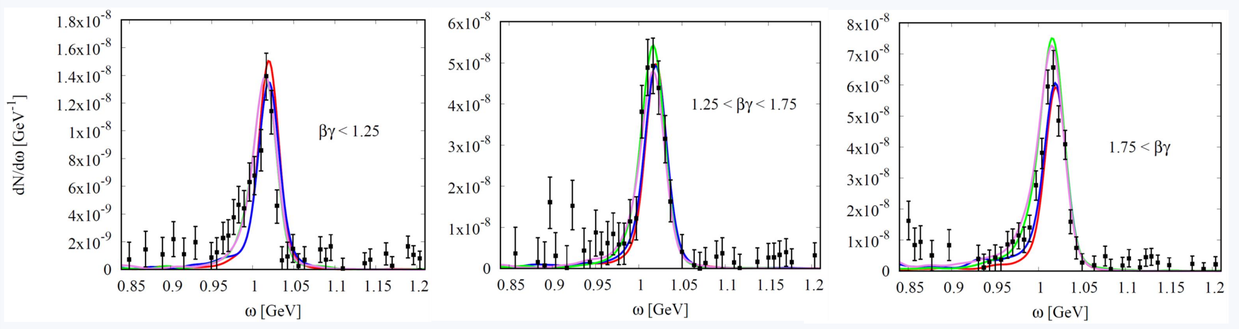
Results

the dilepton spectrum around the ϕ energy (without acceptance corrections or finite resolution effects)



A first direct comparison with the background subtracted experimental data of the E325 experiment

All preliminary



(with acceptance corrections and finite resolution effects)