The near-threshold production of ϕ mesons in pN collisions

Irakli Keshelashvili for the ANKE collaboration

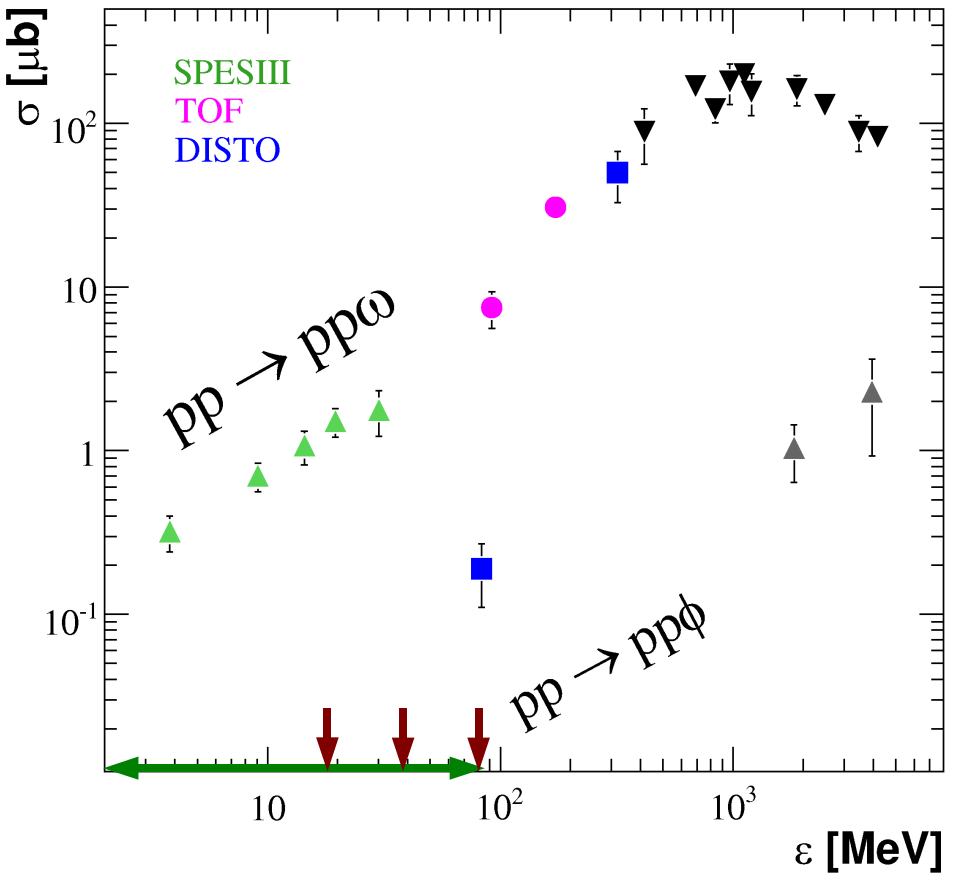
IHEPI TSU and FZJ

(I.Keshelashvili@FZ-Juelich.de)

Outline

- Motivation
- Experiment & Analysis
- Results: $pp \to pp\phi$ & $pn \to d\phi$
- Summary and Outlook

Motivation: ϕ meson production in pN collisions



scares $pp \to pp\phi$ data

no $pn \to d\phi$ data

- energy dependence of the total ϕ cross section $\Rightarrow g_{\phi NN}$
- isospin dependence
- m_ϕ = 1019 MeV (distance of two colliding nucleons < 0.2fm)
- $\phi = \langle \bar{s}s \rangle$

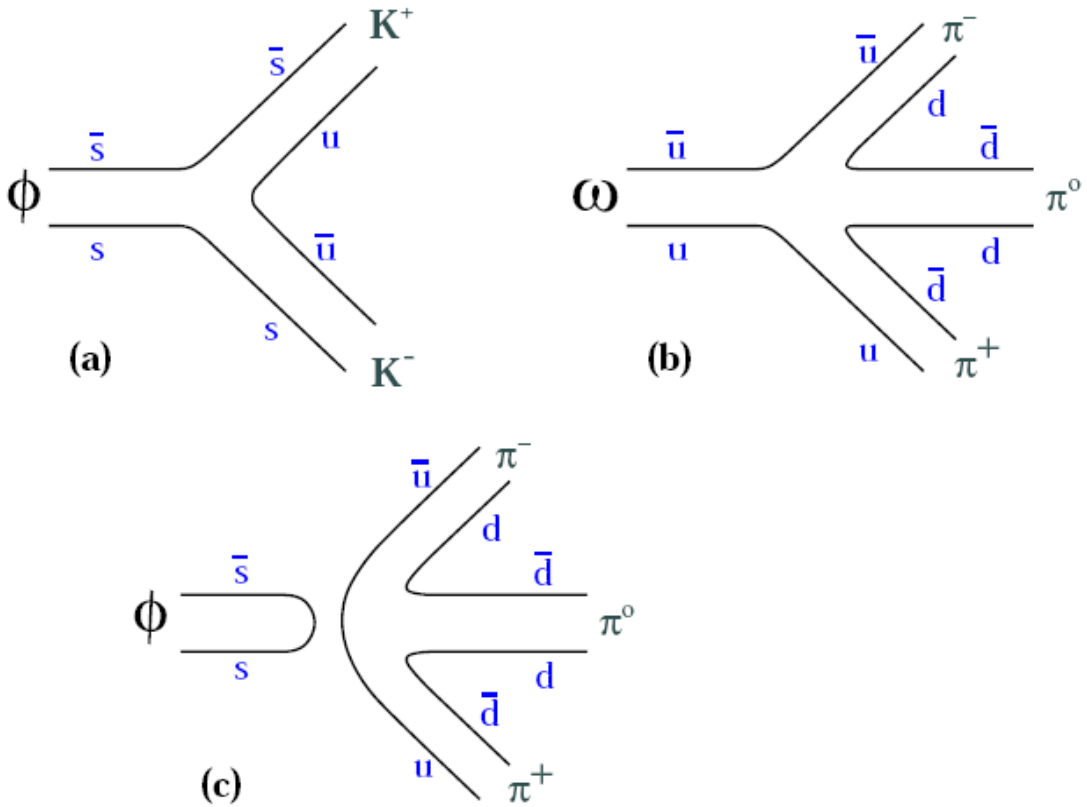
Okubo-Zweig-Iizuka (OZI) rule

At ANKE: (pp) ε = 18.5, 34.6, 75.9 MeV
(pn) ε up to 80 MeV

Motivation: OZI rule

SU(3): $|\omega\rangle_1 = \frac{1}{\sqrt{3}}\left(|u\bar{u}\rangle + |d\bar{d}\rangle + |s\bar{s}\rangle\right)$ $\quad |\phi\rangle = \cos\theta_V |\omega\rangle_8 - \sin\theta_V |\omega\rangle_1 \approx |s\bar{s}\rangle$

$|\omega\rangle_8 = \frac{1}{\sqrt{6}}\left(|u\bar{u}\rangle + |d\bar{d}\rangle - 2|s\bar{s}\rangle\right)$ $\quad |\omega\rangle = \cos\theta_V |\omega\rangle_8 + \sin\theta_V |\omega\rangle_1 \approx \frac{1}{\sqrt{2}}\left(|u\bar{u}\rangle + |d\bar{d}\rangle\right)$



$\sigma_\phi/\sigma_\omega = \tan^2(\theta - \theta_i) = 4.2\times10^{-3} \equiv R_{OZI}$

$\bar{p}p$ annihilation

C.Amsler, Rev.Mod.Phys.70 (1998)

$R_{\phi/\omega} \approx (30 \div 70)\times R_{OZI}$

Mesonic and radiation decay

πN, pp collision (ε>100MeV)

$R_{\phi/\omega} \approx 3\times R_{OZI}$

DISTO @ SATURNE (Saclay, France)

σ_{tot}=200nb @ ε=83MeV

$R_{\phi/\omega} \approx 7\times R_{OZI}$

Experiment: ANKE Set-up @ COSY

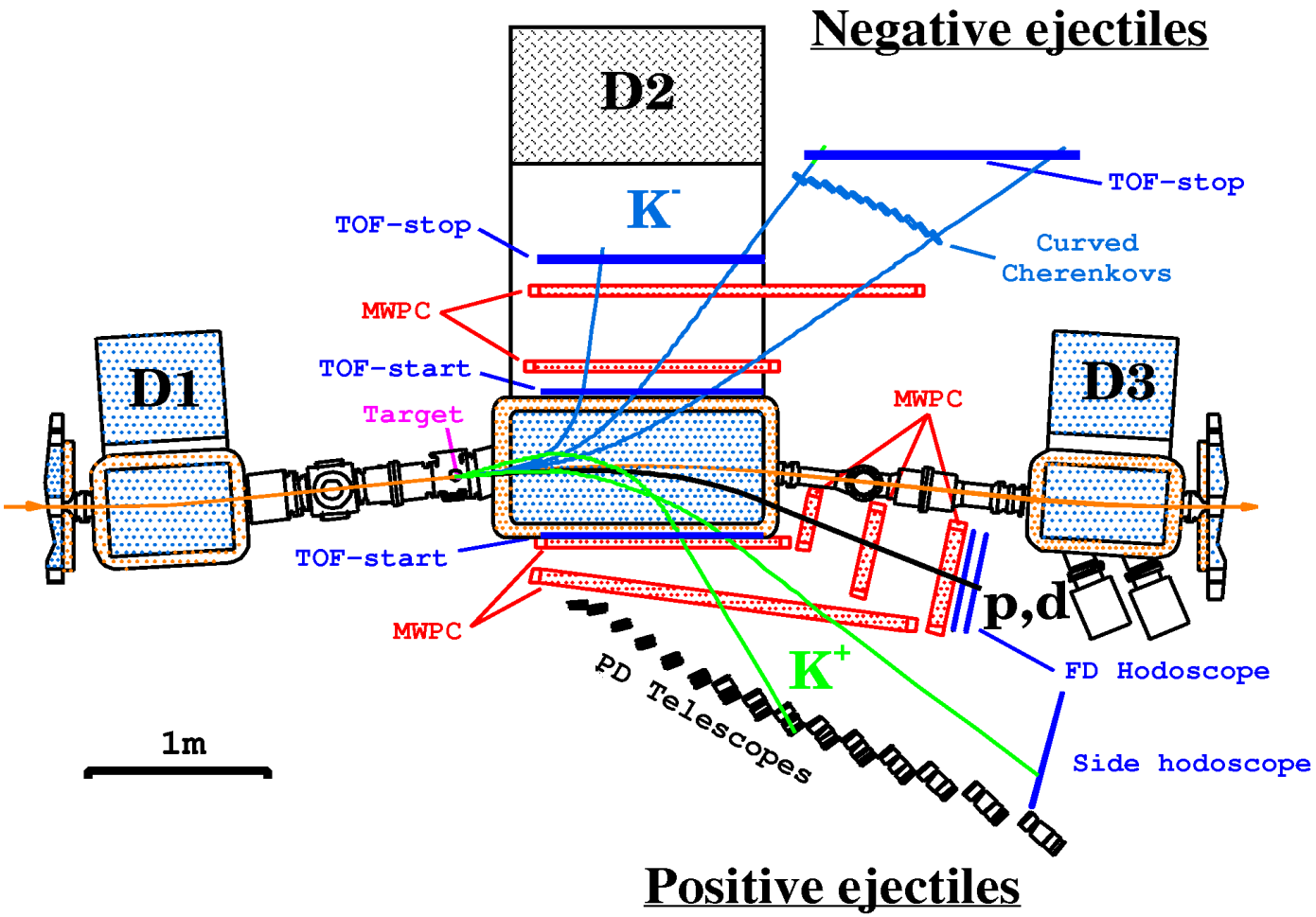
$pp \rightarrow pp\phi \rightarrow pK^+K^-p$

- ✓ 2.83 GeV (75.9 MeV)
- ✓ 2.70 GeV (34.6 MeV)
- ✓ 2.65 GeV (18.5 MeV)

  2.83 GeV (75.9 MeV)

$pd \rightarrow d\phi\, p \rightarrow dK^+K^-p$

- ✓ 2.65 GeV



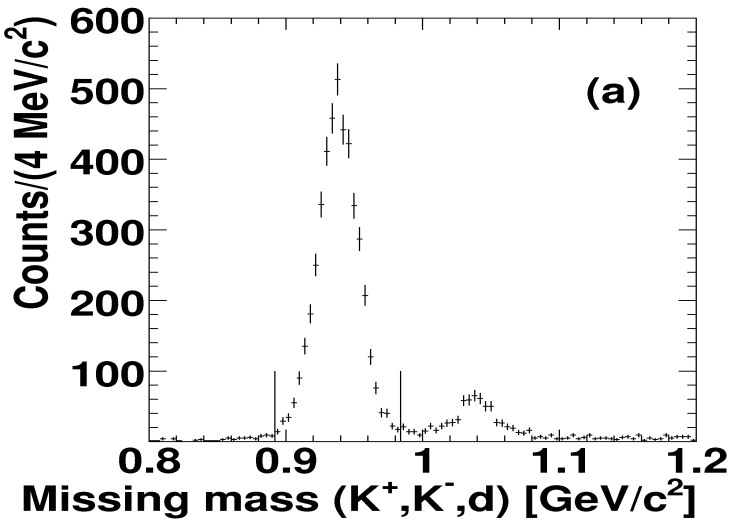
Analysis: Particle/Reaction Identification

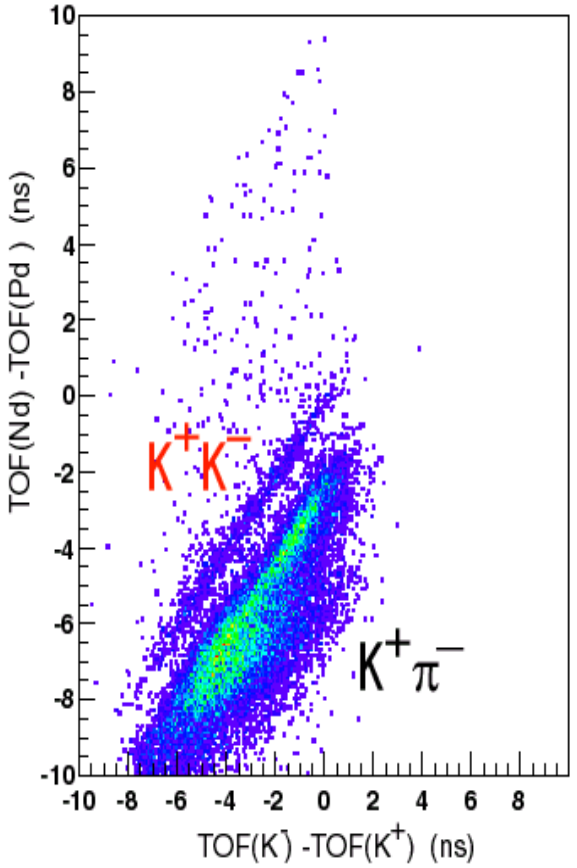
Identification

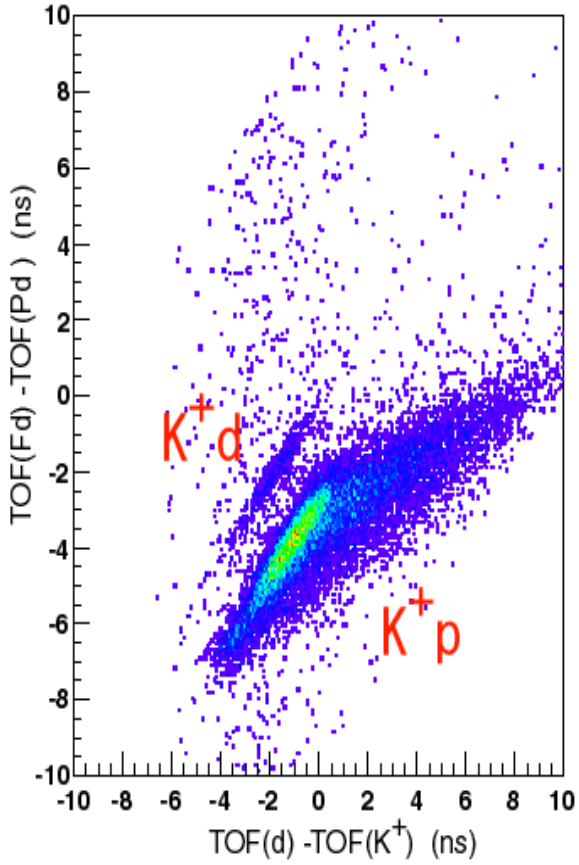
- ✓TOF
- ✓Missing mass

$pp \rightarrow pK^+K^-p$

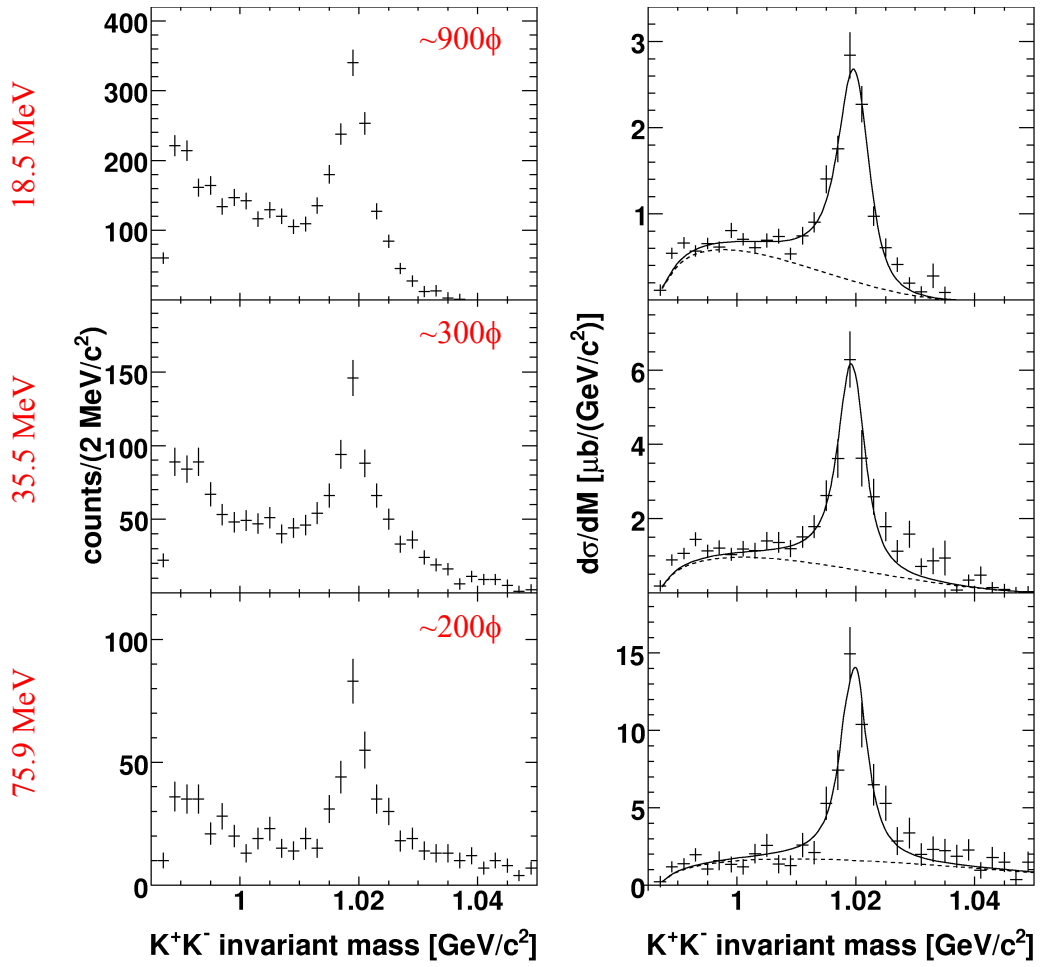
$pd \rightarrow dK^+K^-p$

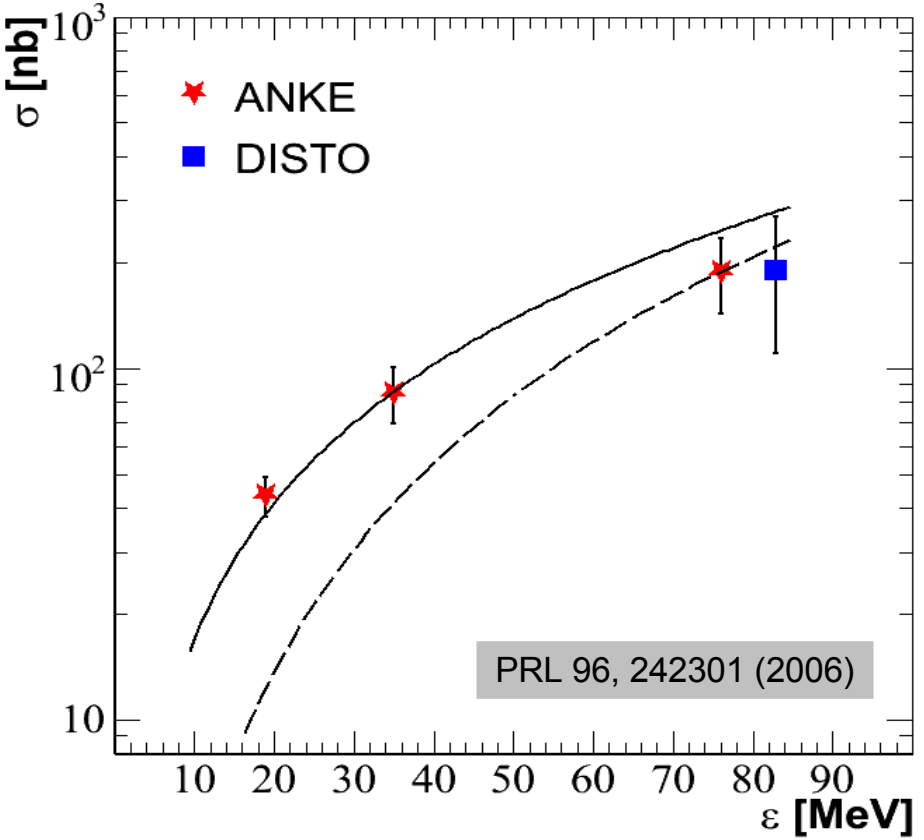






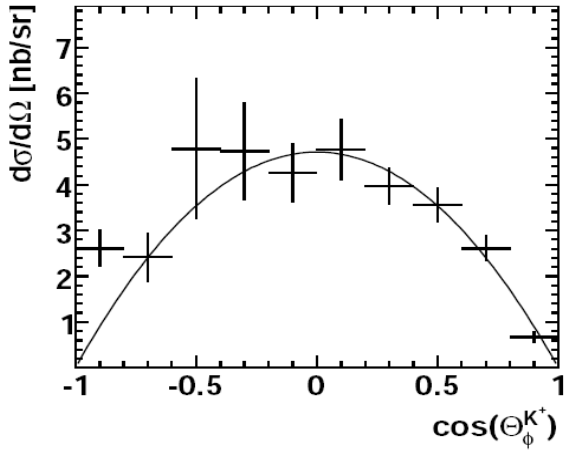
Results: pp→ppϕ (total cross sections)





dashed line: phase space
solid line: phase space + pp-FSI (Jost function - best fit to the ANKE points)

Results: pp→ppϕ (differential cross sections)



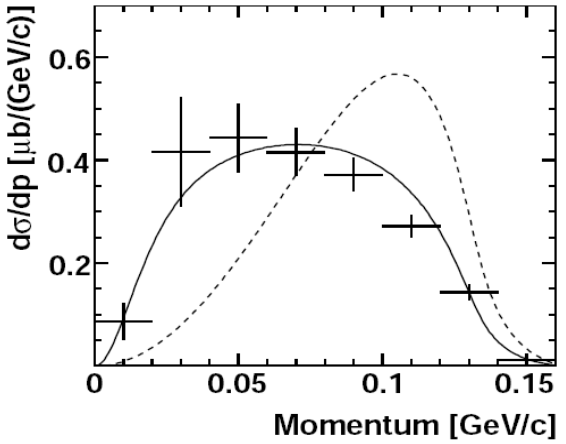
ε = 18.5 MeV

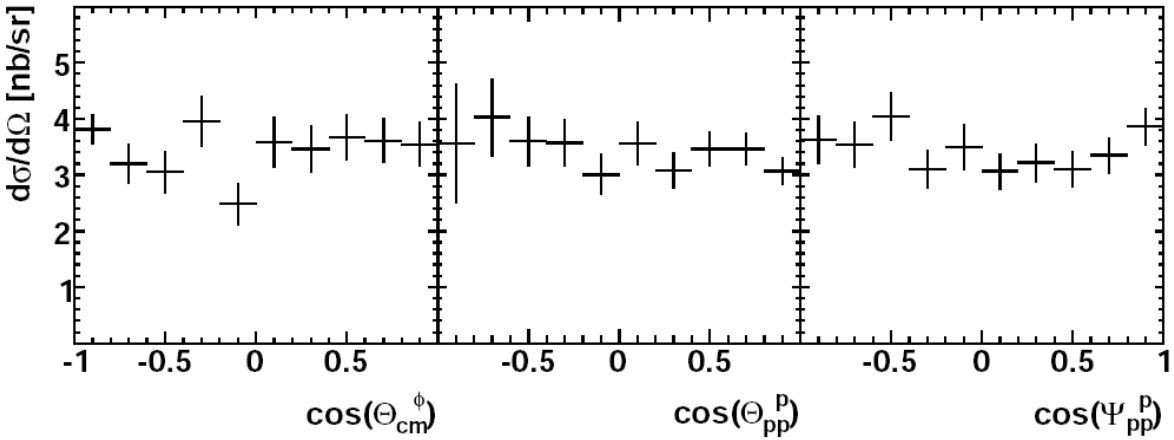
$^1S_0$ (pp) final-state (pp)

ϕ in relative S-wave respect (pp)

$^3P_1$ (pp)-entrance channel

clear transition





clear effect of pp-FSI !!!

Results: The ϕ/ω production ratio

OZI: high energy

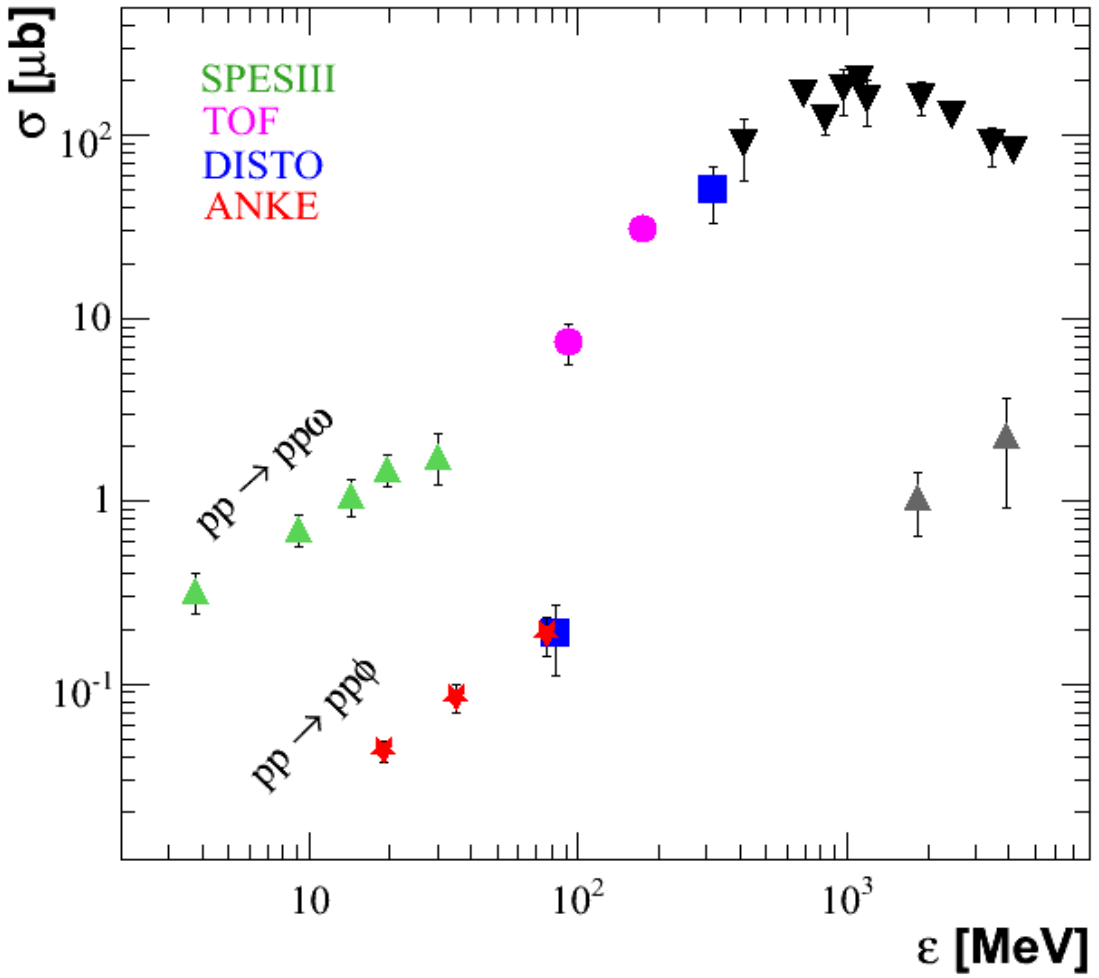
$R_{\phi/\omega} \approx (1 - 2.4) \times R_{OZI}$

(in agreement with πN data and the $\phi\rho\pi$ and $\omega\rho\pi$ coupling)

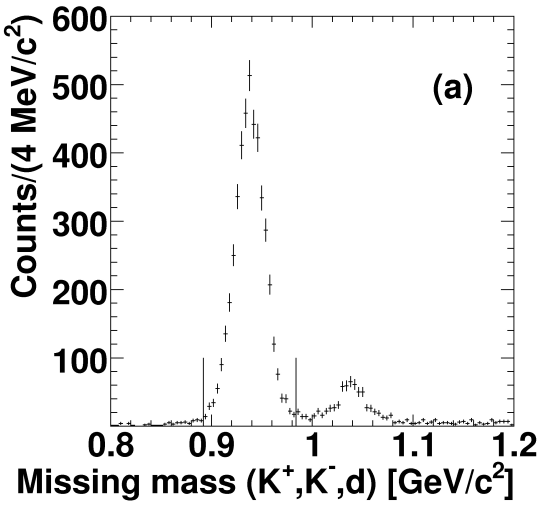
-ANKE

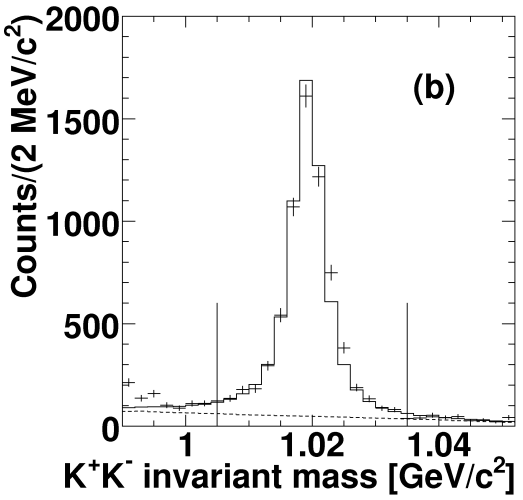
OZI: 18.5-79.5 MeV

$R_{\phi/\omega} \approx (3.3 \pm 0.6) \times 10^{-2} \approx 8 \times R_{OZI}$



Results: pn→dϕ (event selection)

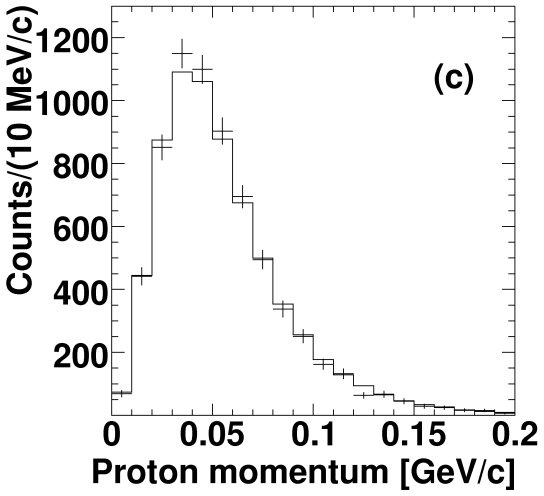


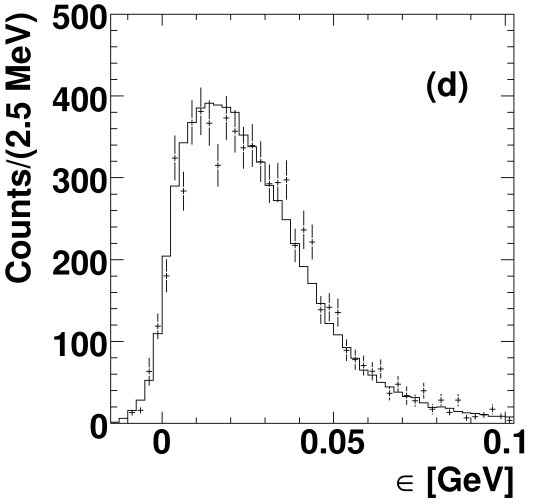


T_p = 2.65 GeV

$$pd \rightarrow d\phi(K^+K^-)p_{spectator}$$

$$pn \rightarrow d\phi(K^+K^-)$$





Monte Carlo simulation:

Fermi momentum in the target deuteron derived from Bonn potential.

$\sigma_\varepsilon \approx 2$ MeV

extract cross section ‹ 80 MeV

Results: pn→dϕ (differential cross sections)

1S+9 possible P-wave amplitudes!

				Ll_{J_q}
$^1P_1$	→	$^3S_1$	s	Ss
$^3S_1$	→	$^3S_1$	p	S^1p_0
$^3S_1$	→	$^3S_1$	p	S^1p_1
$^3S_1$	→	$^3S_1$	p	S^1p_2
$^3D_1$	→	$^3S_1$	p	S^2p_0
$^3D_1$	→	$^3S_1$	p	S^2p_1
$^3D_1$	→	$^3S_1$	p	S^2p_2
• • •				

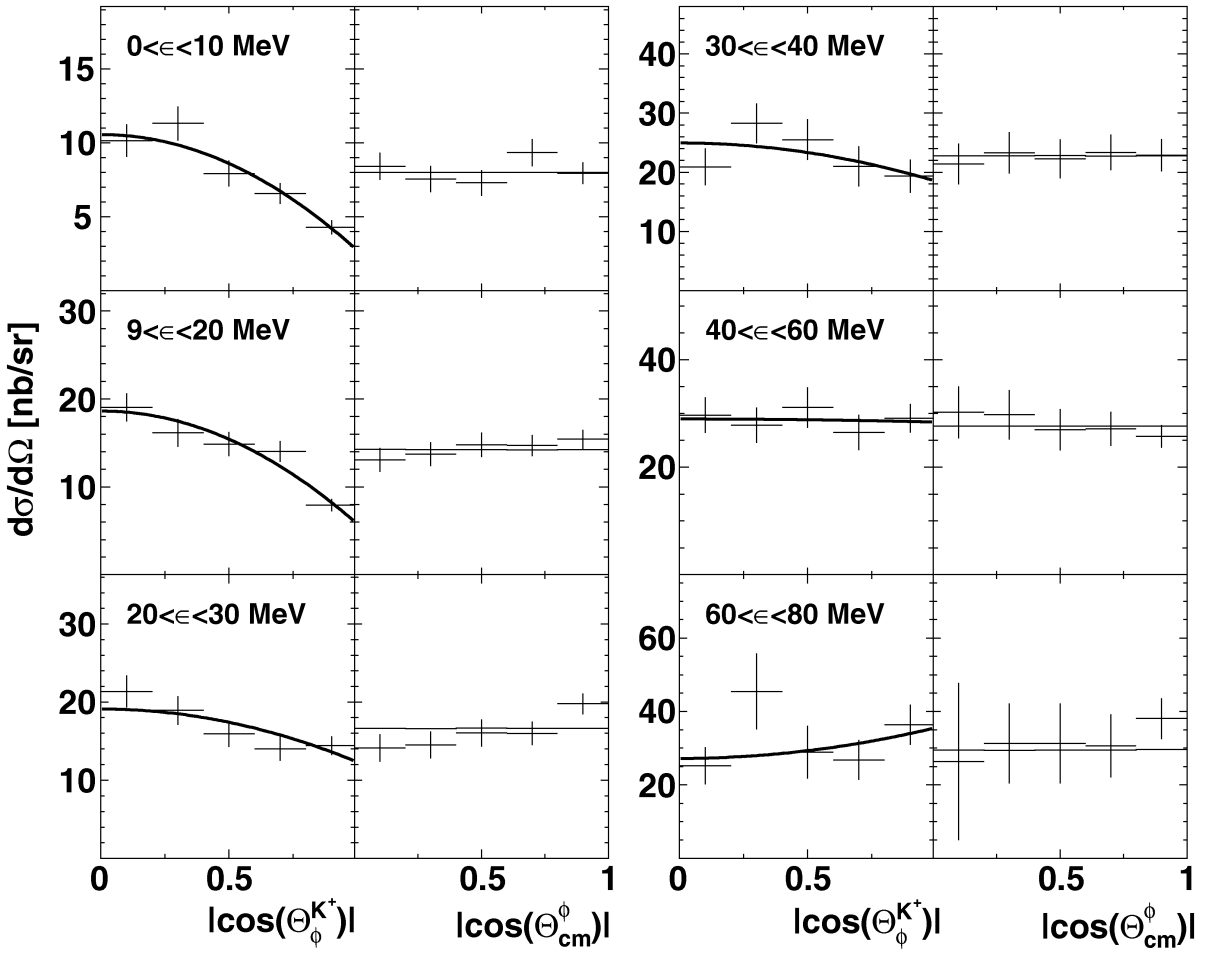
to allow for the possibility
of higher partial waves ...
most general form:

$$d\sigma/d\Omega_\phi^{K^+} =$$

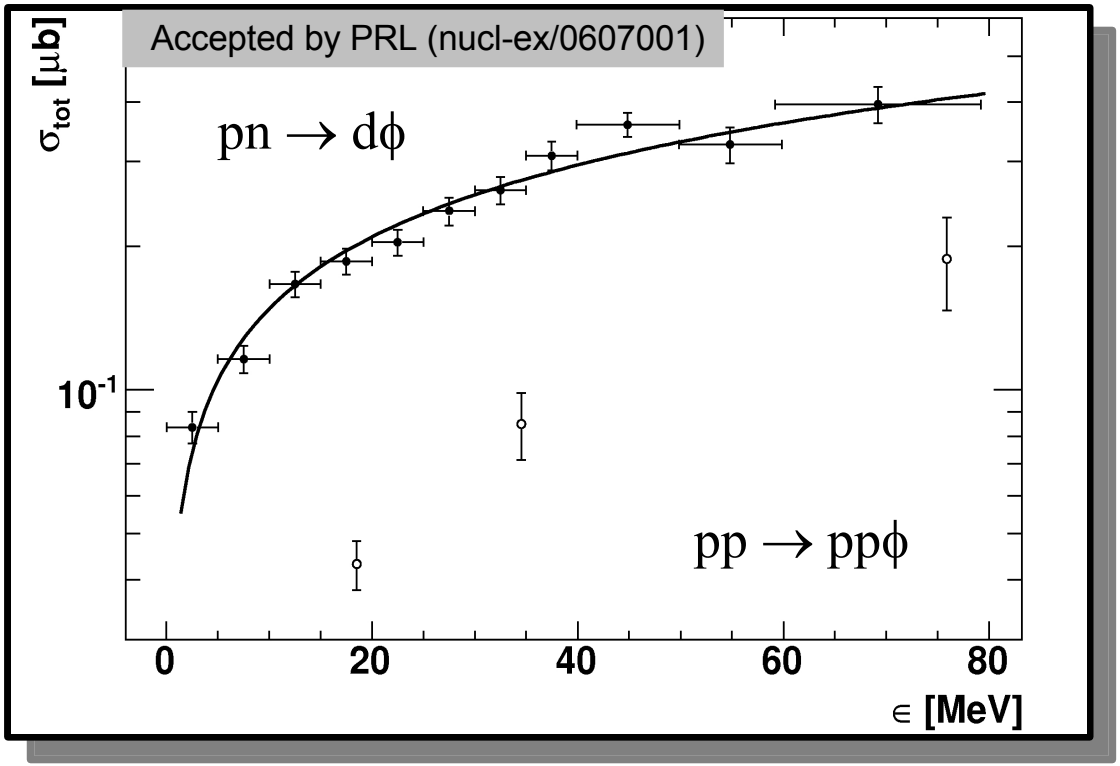
$$= 3/(8\pi)(a \sin^2\Theta_\phi^{K^+} + 2b \cos^2\Theta_\phi^{K^+})$$

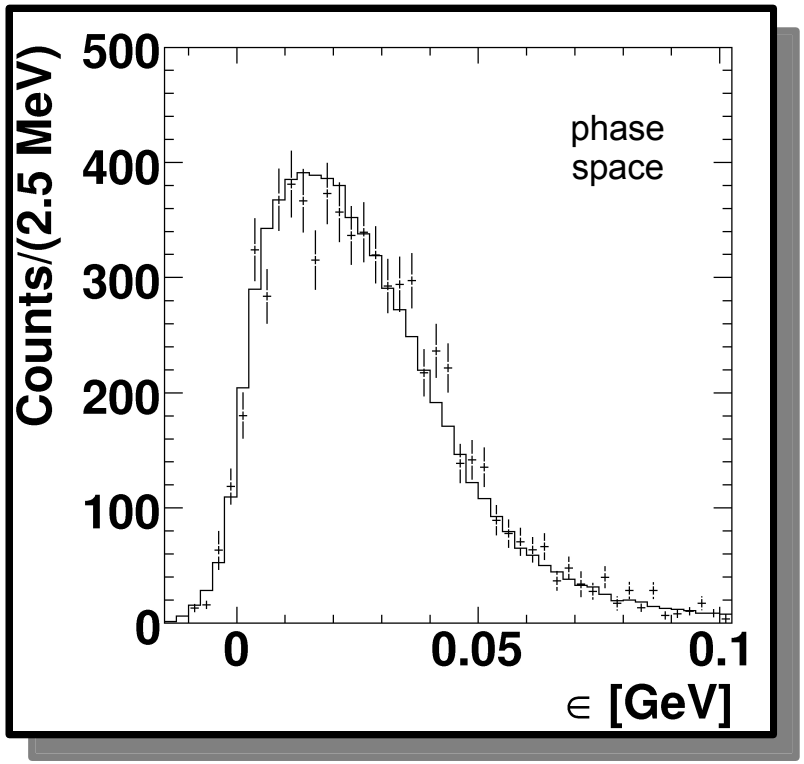
$$\sigma_{tot} = a+b$$

from fits to these data:
$b/a \approx (0.012 \pm 0.001)(\varepsilon/\text{MeV})$



Results: pn→dϕ (total cross sections)





using final-state-interaction theory
(G. Faeldt and C. Wilkin, Phys. Lett. B. 382 (1996) 209).

$\sigma(pn \to pn\phi) / \sigma(pp \to pp\phi) \approx 2.3 \pm 0.4$

Summary and outlook

$pp \to pp\phi$ (ε=18.5, 34.5 and 75.9 MeV)

ε=18.5 MeV, S-wave production

($^3P_1 \to {}^1S_0$ transition)

clear pp-FSI (energy dependence)

OZI: $R_{\phi/\omega}$(18.5-79.5 MeV)

$\approx (3.3 \pm 0.6) \times 10^{-2} \approx 8 \times$Rozi

$pn \to d\phi$ (Tp=2.65 GeV, ε up to 80 MeV)

σ_{tot} phase-space energy dependence

P-wave contribution already at low energy

OZI: $R_{\phi/\omega}$ ($\approx$ 60 MeV)

$\approx (4.0 \pm 1.9) \times 10^{-2} \approx 9 \times$Rozi

new $pp \to pp\phi$ data at ε=75.9 MeV

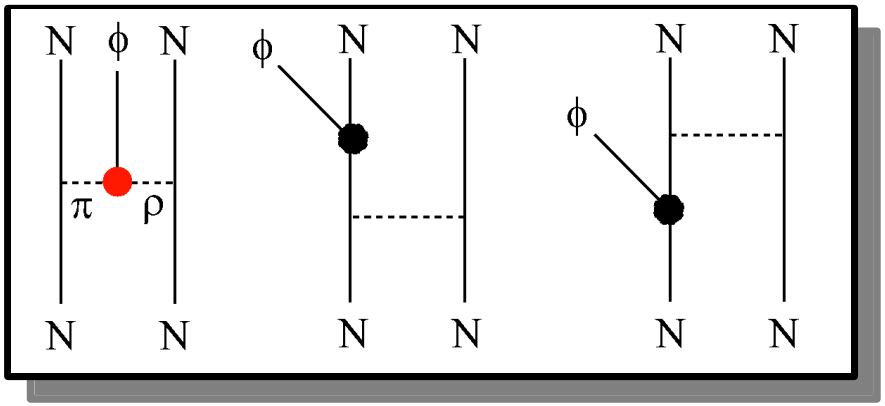
($\approx$ 3000 ϕ's)

higher partial wave contribution ??

Results: pp→ppϕ compared with theoretical predictions

K. Tsushima and K. Nakayama,
Phys. Rev. C 68 (2003) 034612.

L.P. Kaptari and B. Kaempfer,
Eur. Phys. J. A 23 (2005) 291.



A. Faessler *et al.*,
Phys. Rev. C 68 (2003) 068201.
(resonance model, two step)