

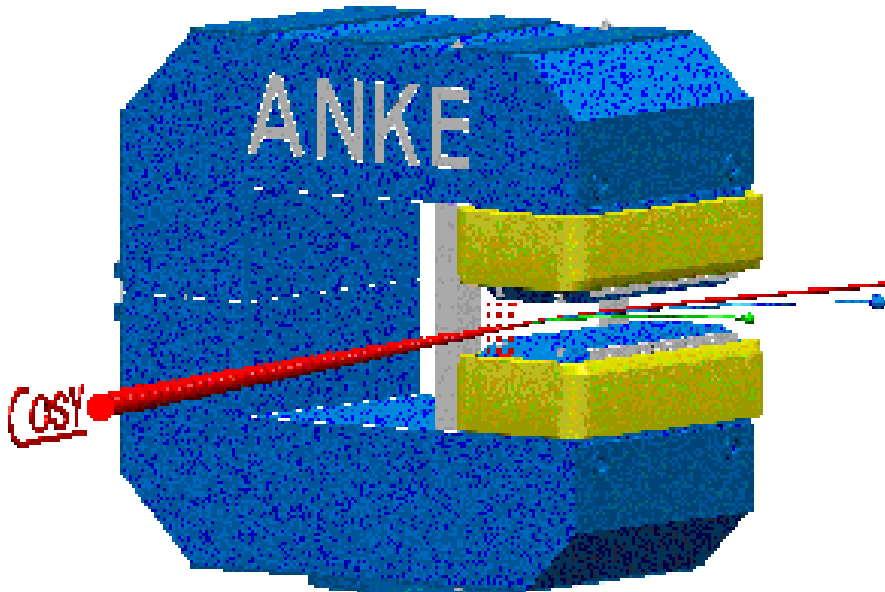
Near-threshold production of ϕ -meson in pN collisions at COSY-ANKE facility

Yoshikazu Maeda

On behalf of the ANKE collaboration

Research Center Jülich, Germany
and

Research Center for Nuclear Physics, Osaka Univ.



● Reactions

✓ $pp \rightarrow pp\phi$

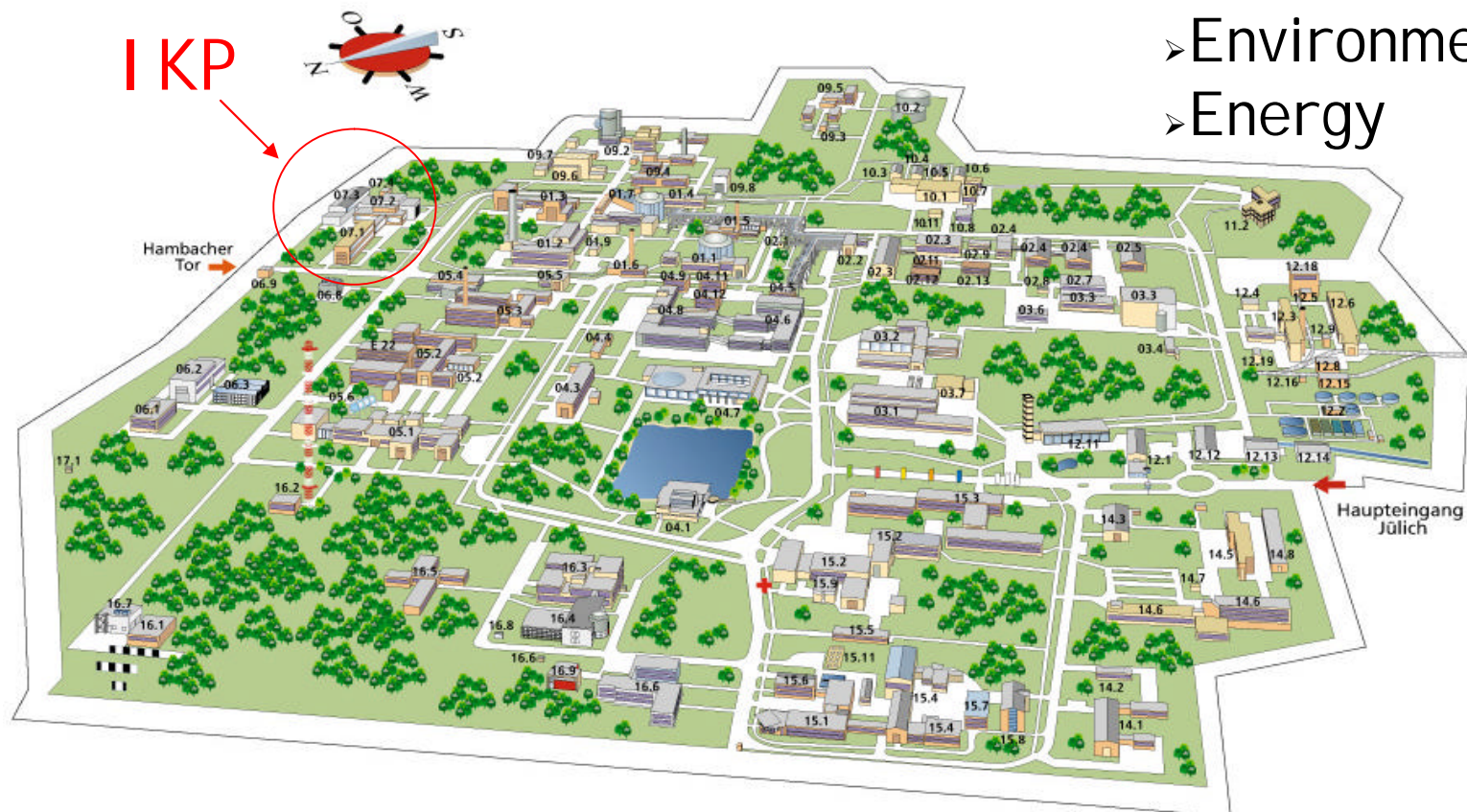
M. Hartmann et al, PRL96,242301(2006)

✓ $pn \rightarrow d\phi$

Y. Maeda et al, PRL97,142301(2006)

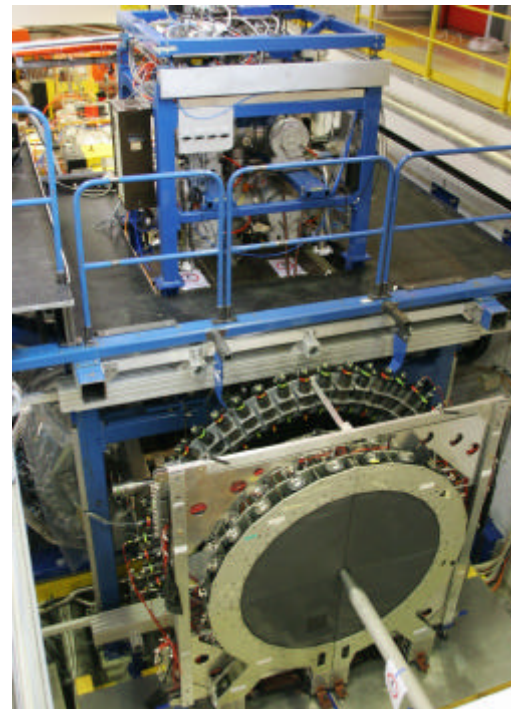
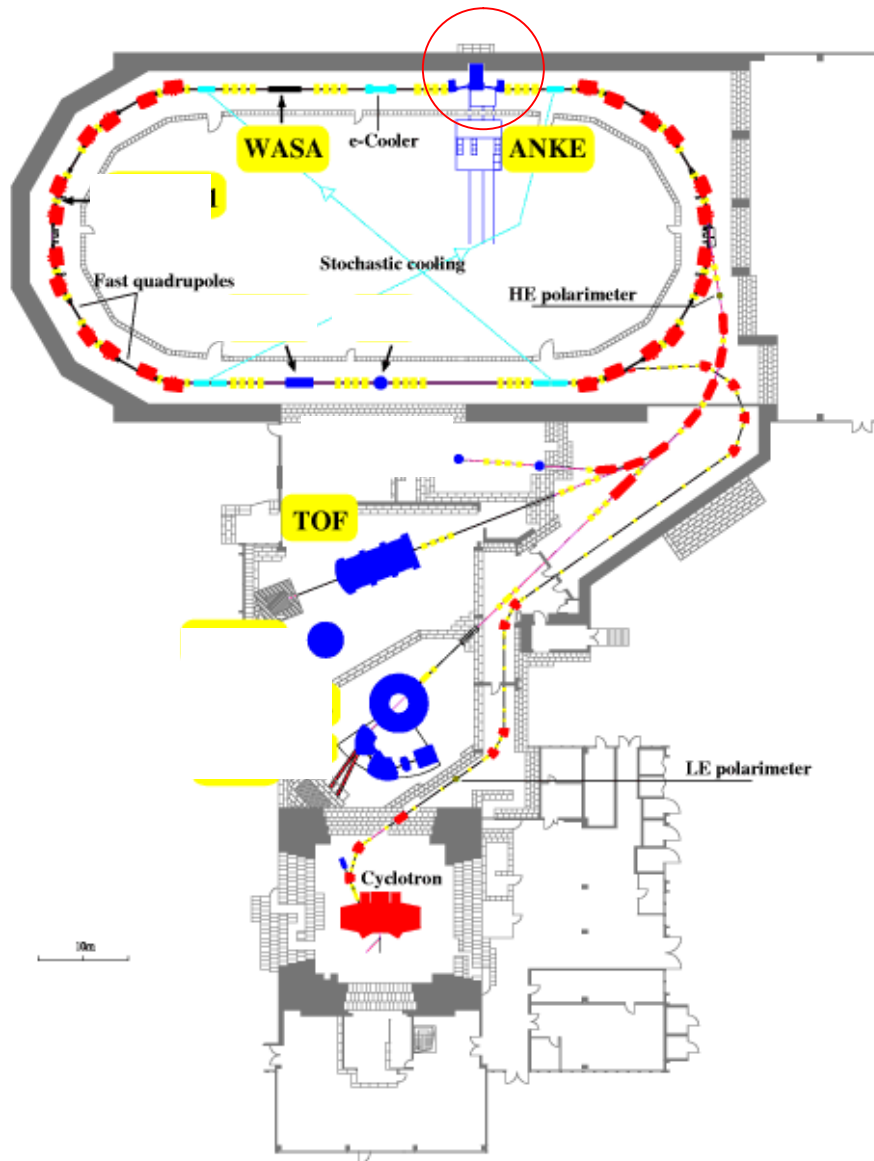
Where is Jülich?

- Health
- Information
- Environment
- Energy



<http://www.fz-juelich.de/>

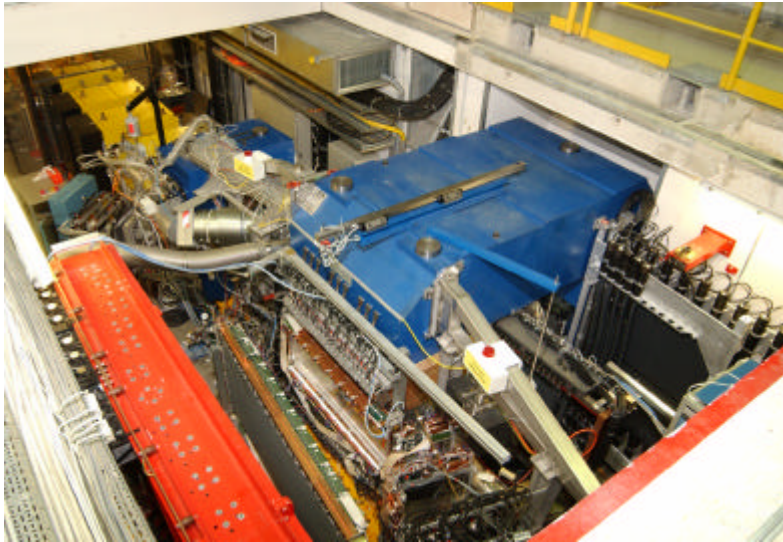
The Accelerator: COSY-Jülich



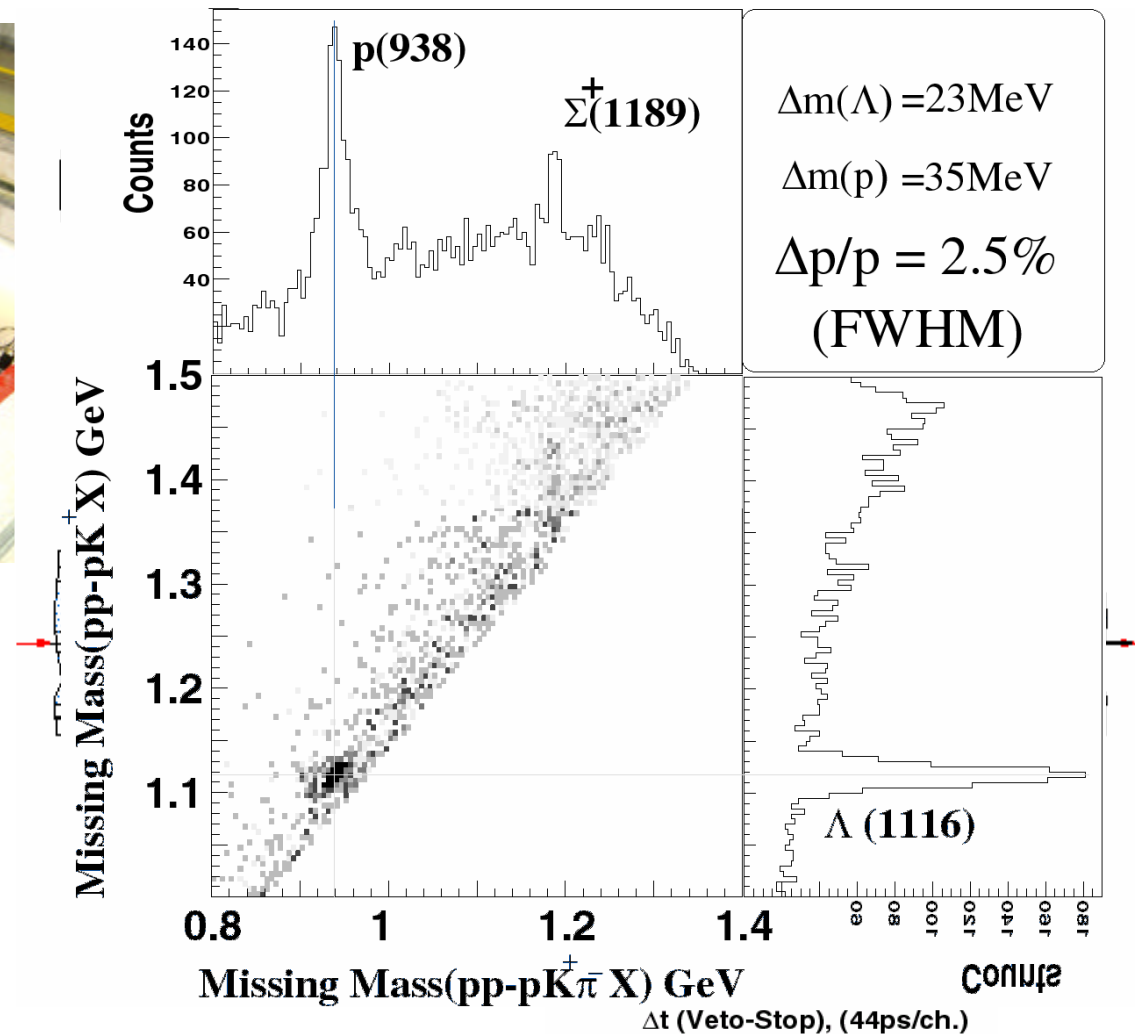
ANKE

Apparatus for Studies of Nucleon and Kaon Ejectiles

S. Barsov et al., Nucl. Instr. Meth. A462(2001)364



- forward spectrometer
- cluster jet target and solid target
- K⁺ detection at 0.2-0.6 GeV/c
- Negative part completed in 2002
- K⁻ detection
- 3-4 charged particles correlation



Physics at ANKE

- K^+ -Meson Production in Nuclei

M.Buescher et al, Eur. Phys. J. A 22, 301-317 (2004)

- Hyperon production

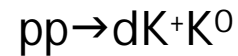


I.Zyclor et al, Phys. Rev. Lett. 96,012002(2006)



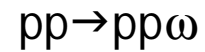
M.Nekipelov et al, Submitted to EPJ

- Meson production

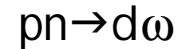


V. Klever et al, Phys. Rev. Lett. 91,172304(2003)

A.Dzyuba et al, Eur. Phys. J. A29, 245(2006)



S.Barsov et al, Submitted to EPJ



S.Barsov et al, Eur. Phys. J. A21, 521 (2004)



This work



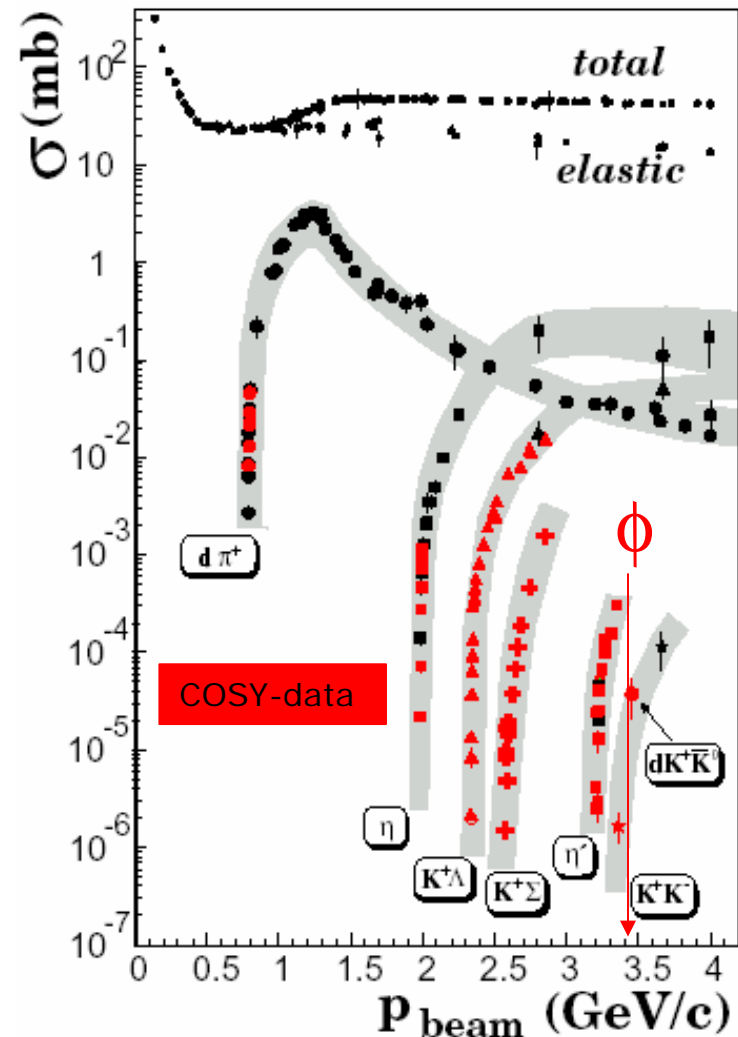
This work

Meson production in NN collisions

- Low momentum in final state
- High momentum transfer
- Meson-Baryon and Baryon Baryons interaction
- Spin-I sospin filter
- Baryon resonance

→

$$m = \pi \eta \eta' K \omega \phi(\bar{s}s)$$



OZI rule

$$R_{\phi/\omega} = \sigma_{\phi} / \sigma_{\omega} = \tan^2 \Delta\theta = 4.2 \times 10^{-3}$$

- $\bar{p}p$ annihilation at LEAR

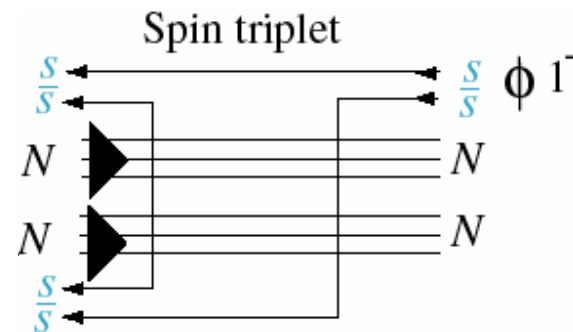
$$R_{\phi/\omega} ? 100 \times R_{\text{OZI}}$$

→ Spin triplet dominance

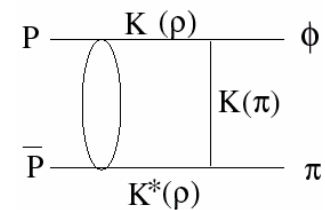
C.Amster, Rev.Mod.Phys.70(1998)

$$B(p\bar{p} \rightarrow \phi\pi^0 : {}^3S_1) = (7.57 \pm 0.62) \times 10^{-4}$$

$$B(p\bar{p} \rightarrow \phi\pi^0 : {}^1P_1) < 0.5 \times 10^{-4}$$



J.Ellis et al Phys. Let. B353(1995)319-328



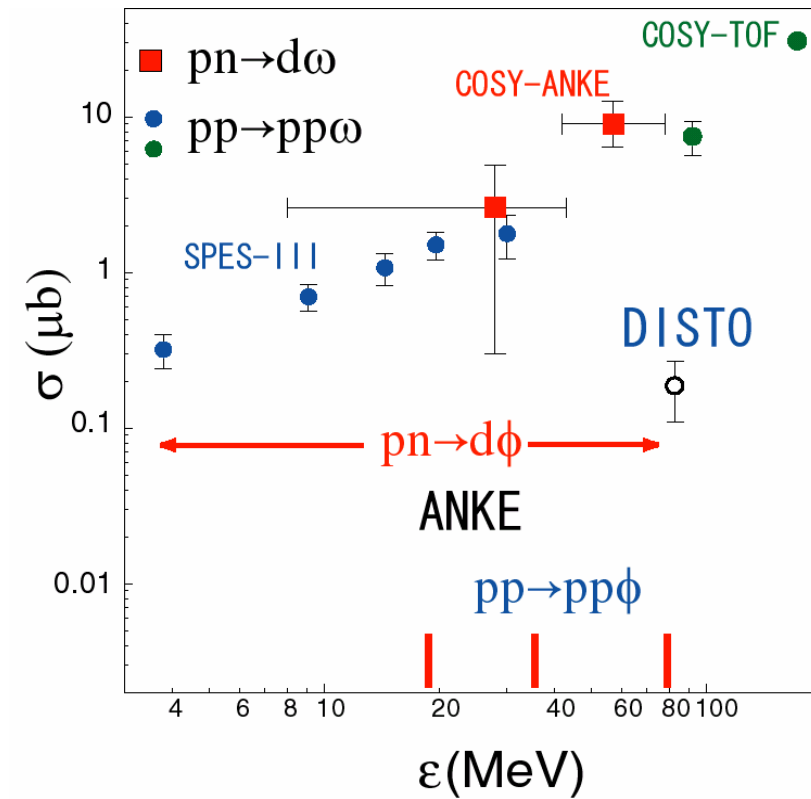
A.I. Titov et al Phys. Rev. C59(1999)999

ϕ/ω -meson production in NN collisions

$$\begin{aligned} \mathcal{S}_t(pp \rightarrow ppv) & \quad {}^3P_1 \rightarrow {}^1S_0 \quad s \\ \mathcal{S}_s(pn \rightarrow dv) & \quad {}^1P_1 \rightarrow {}^3S_1 \quad s \end{aligned}$$

- pp collision at $\epsilon=83$ MeV
 $R_{\phi/\omega} \approx 7 \times R_{\omega ZI}$ (DISTO, TOF)
 Higher partial wave!

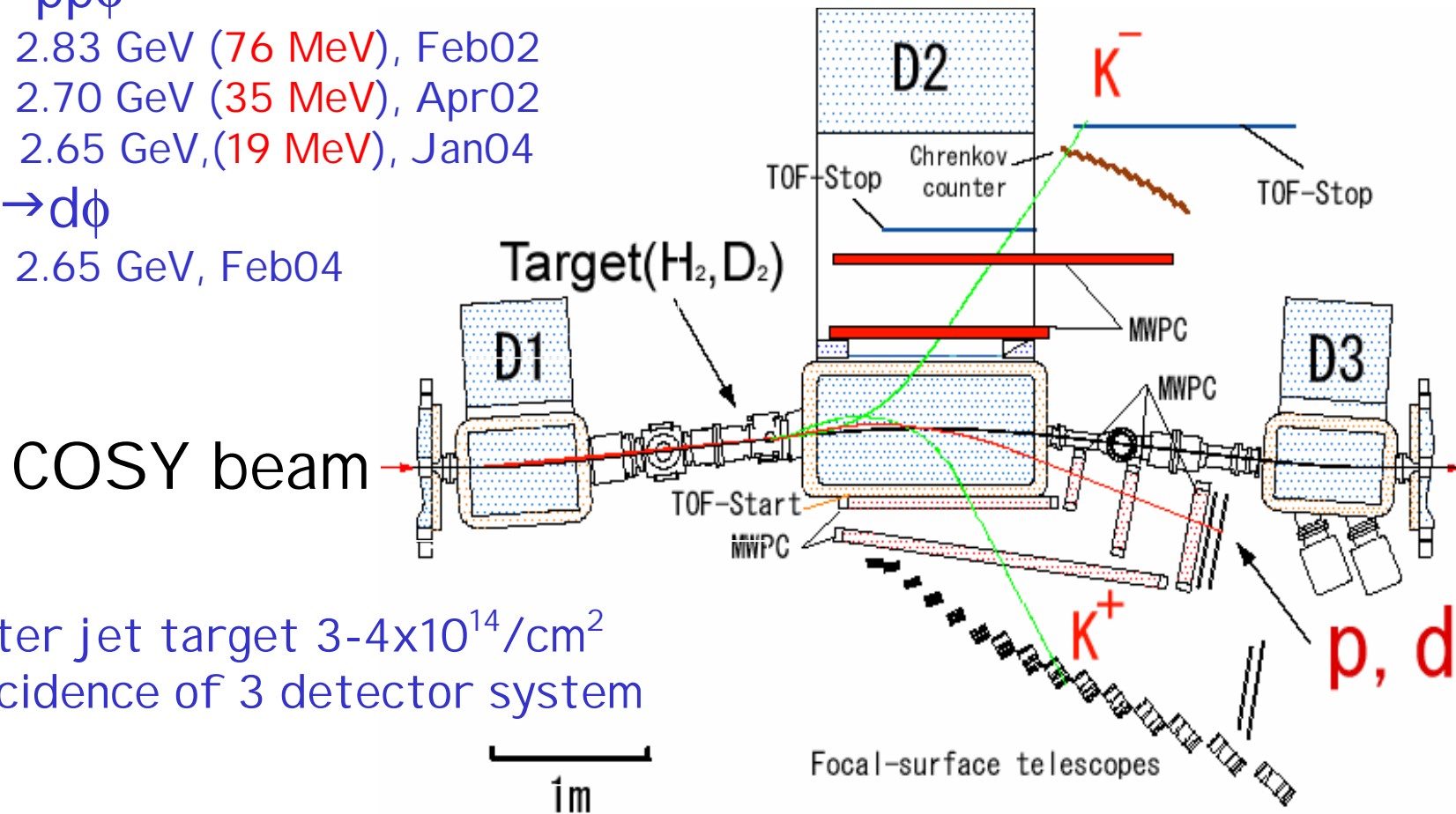
F. Balesta et al., Phys. Rev. C63(2001) 024004
 S.Abd El-Samad et al., Phys Lett. B522,(2001)16



New data $pn \rightarrow d\phi$ \rightarrow Isospin-spin dependence of $R_{\phi/\omega}$.
 Production mechanisms.

Experiment

- $pp \rightarrow pp\phi$
 - ✓ 2.83 GeV (76 MeV), Feb02
 - ✓ 2.70 GeV (35 MeV), Apr02
 - ✓ 2.65 GeV, (19 MeV), Jan04
- $pn \rightarrow d\phi$
 - ✓ 2.65 GeV, Feb04



- Cluster jet target $3-4 \times 10^{14} / \text{cm}^2$
- Coincidence of 3 detector system

Particle identification

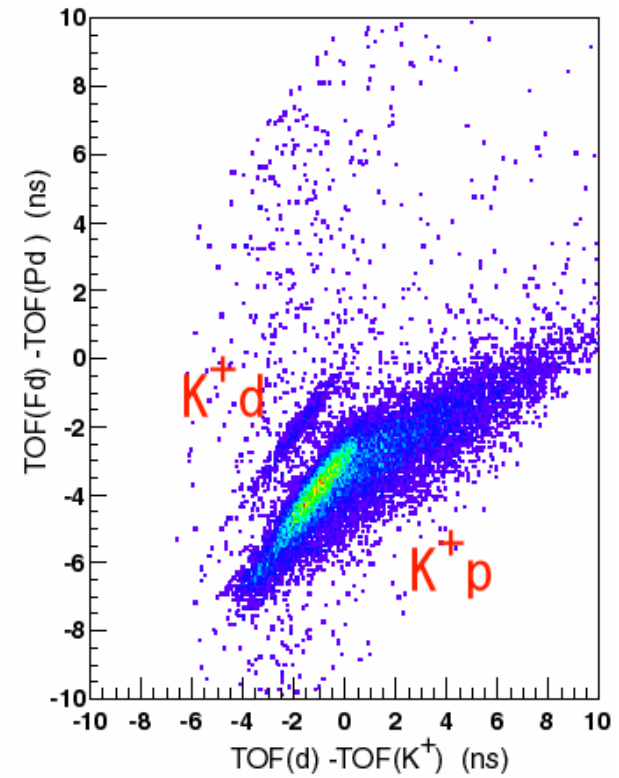
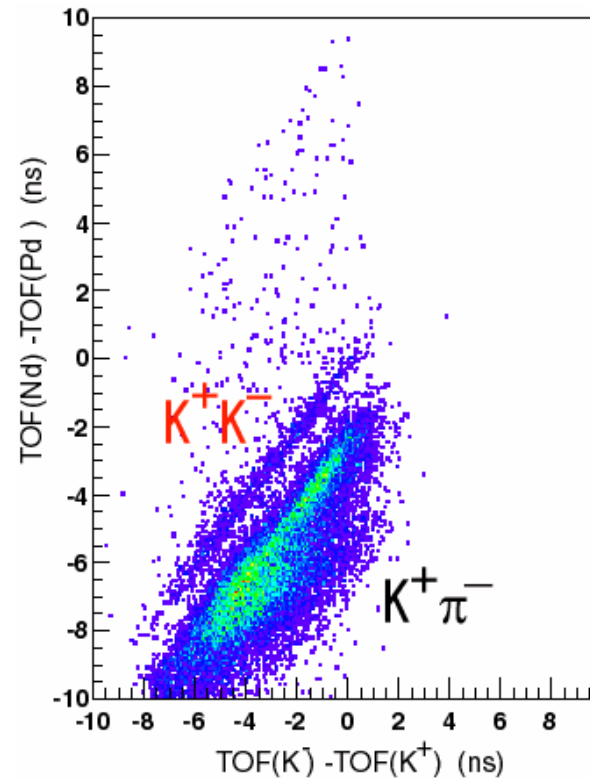
- Identification

- ✓ TOF

- ✓ Missing mass

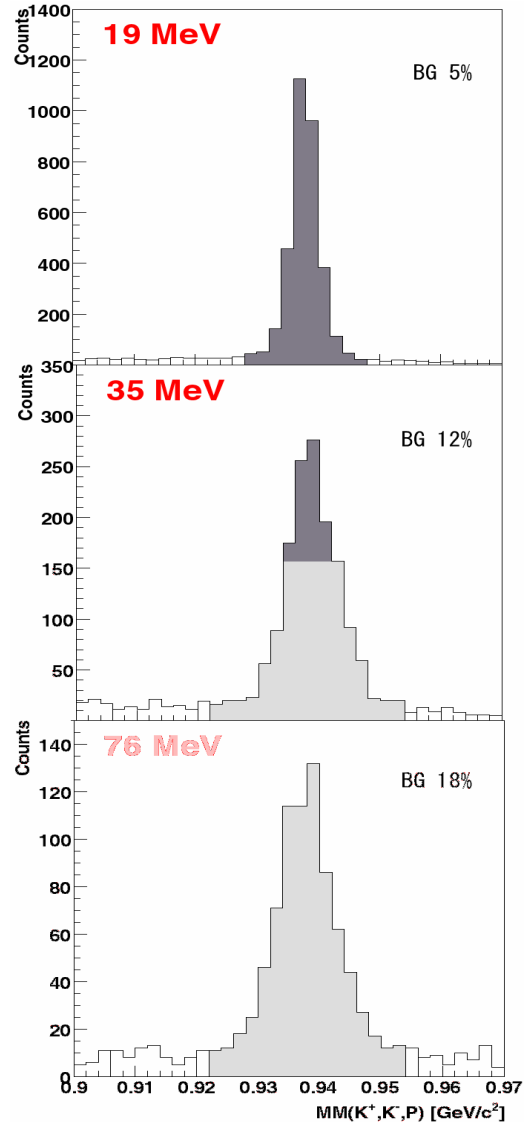
- $pp \rightarrow pK^+K^- p$

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

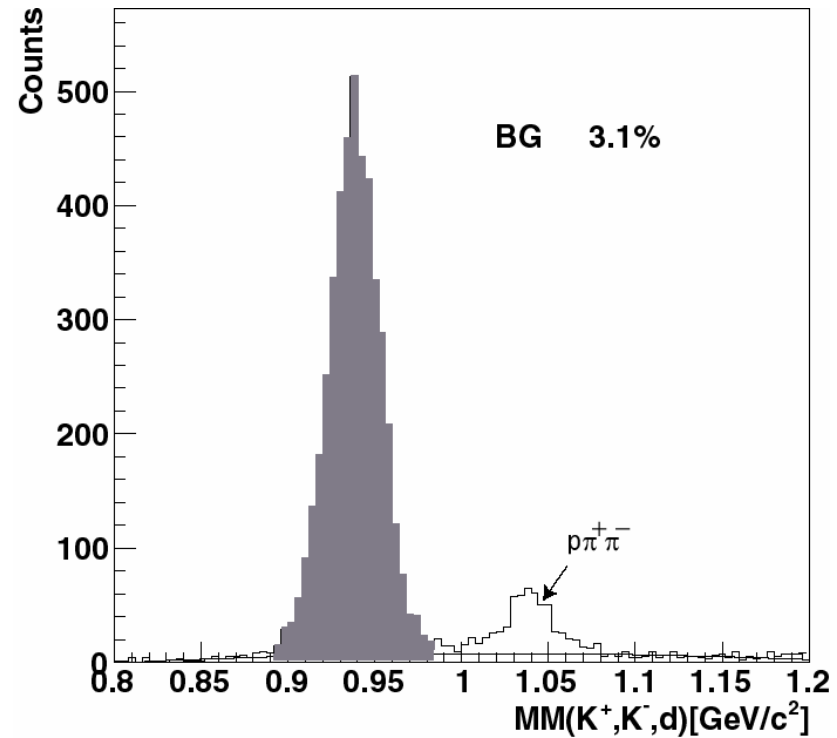


Missing mass distribution

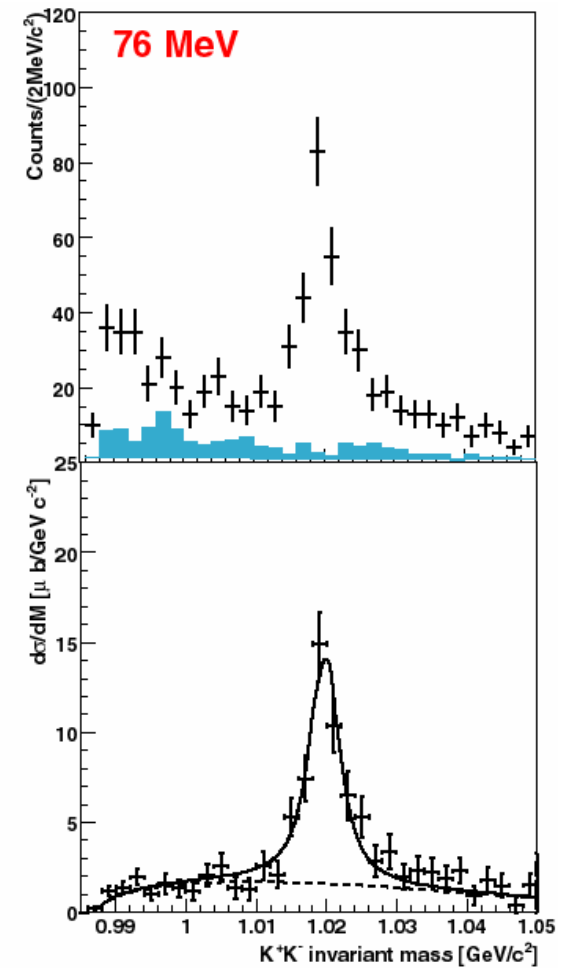
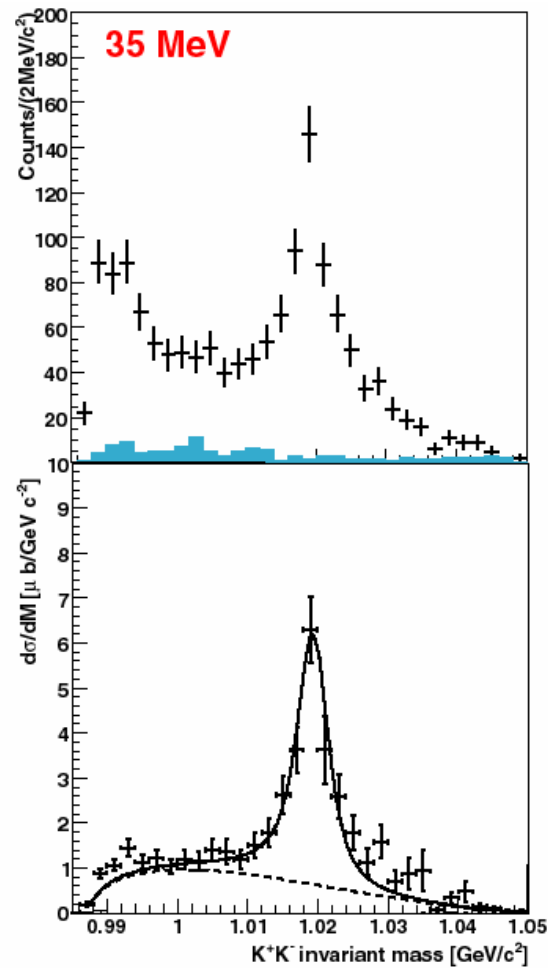
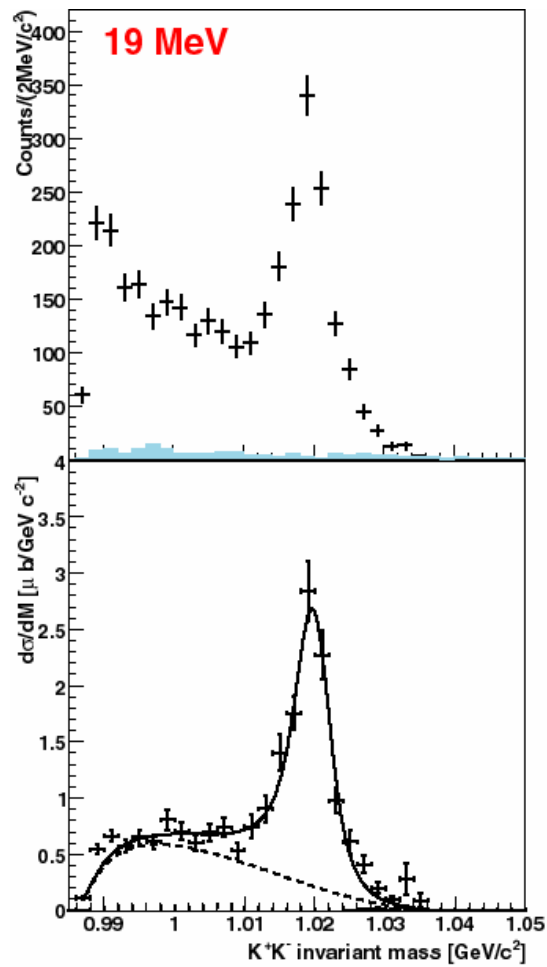
$pp \rightarrow pK^+K^- X$



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

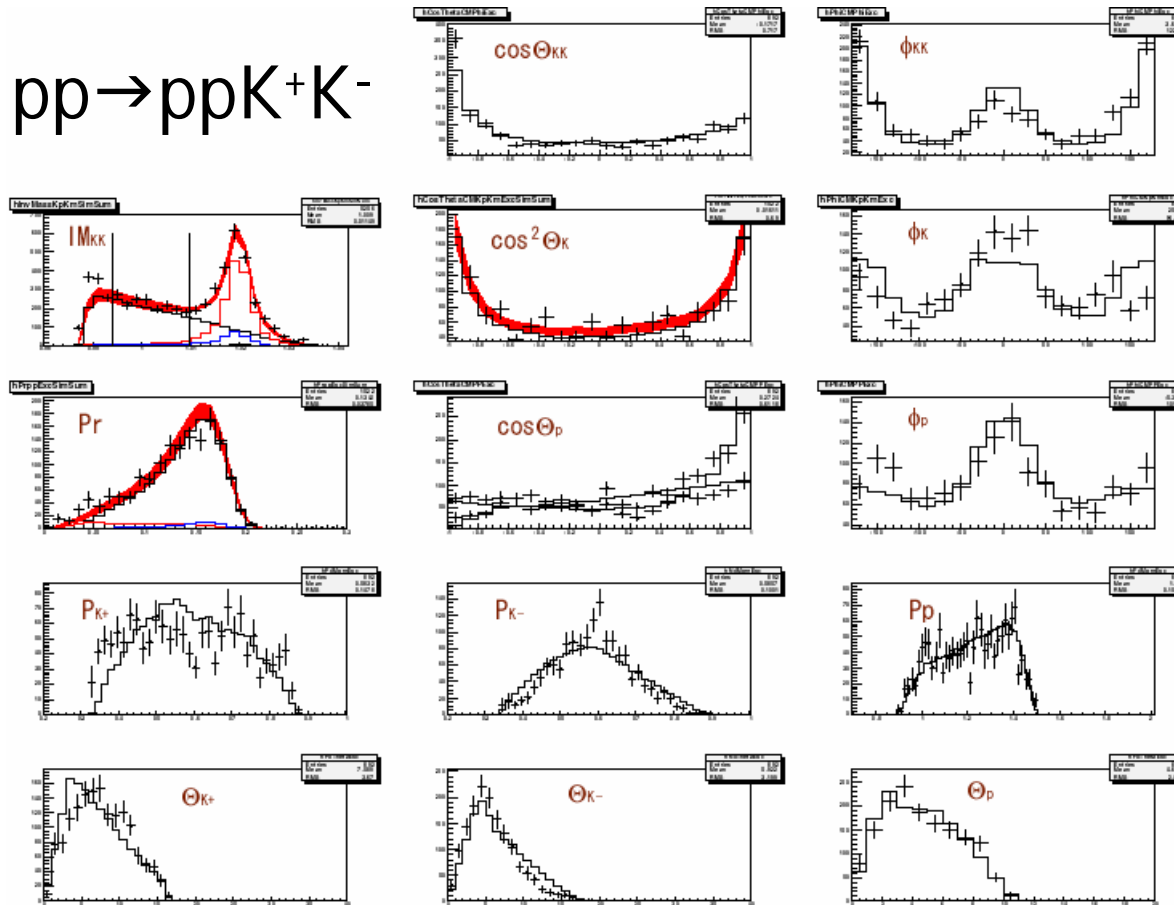


Invariant mass distribution for $pp \rightarrow pp\phi$



Differential distributions

$pp \rightarrow ppK^+K^-$



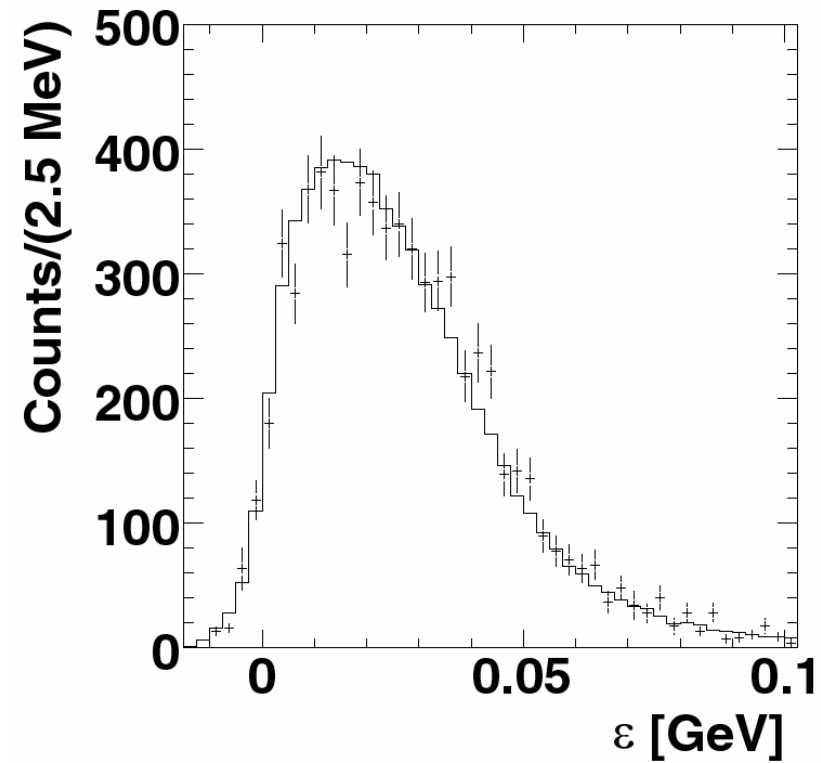
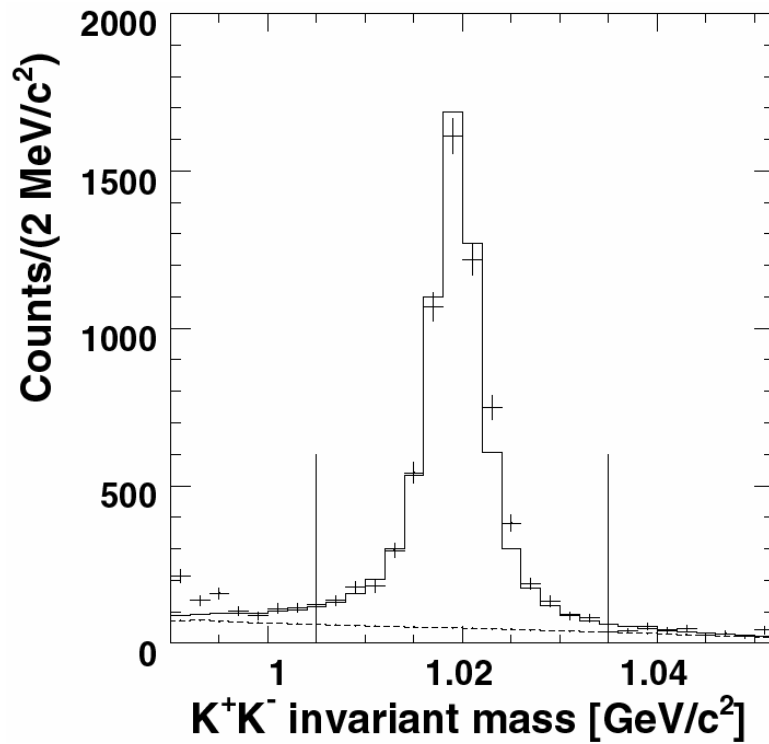
7 indep. variables for
4 body final state in C.M.S

- $|M_{KK}$ inside ϕ -meson cut
FSI effect in pp
 $\sin^2\Theta_K$ dependence

- $|M_{KK}$ outside the cut
Excess below $|M_{KK} \sim 0.993$
Consistent with P.S.
Momentum dep. differs
from P.S

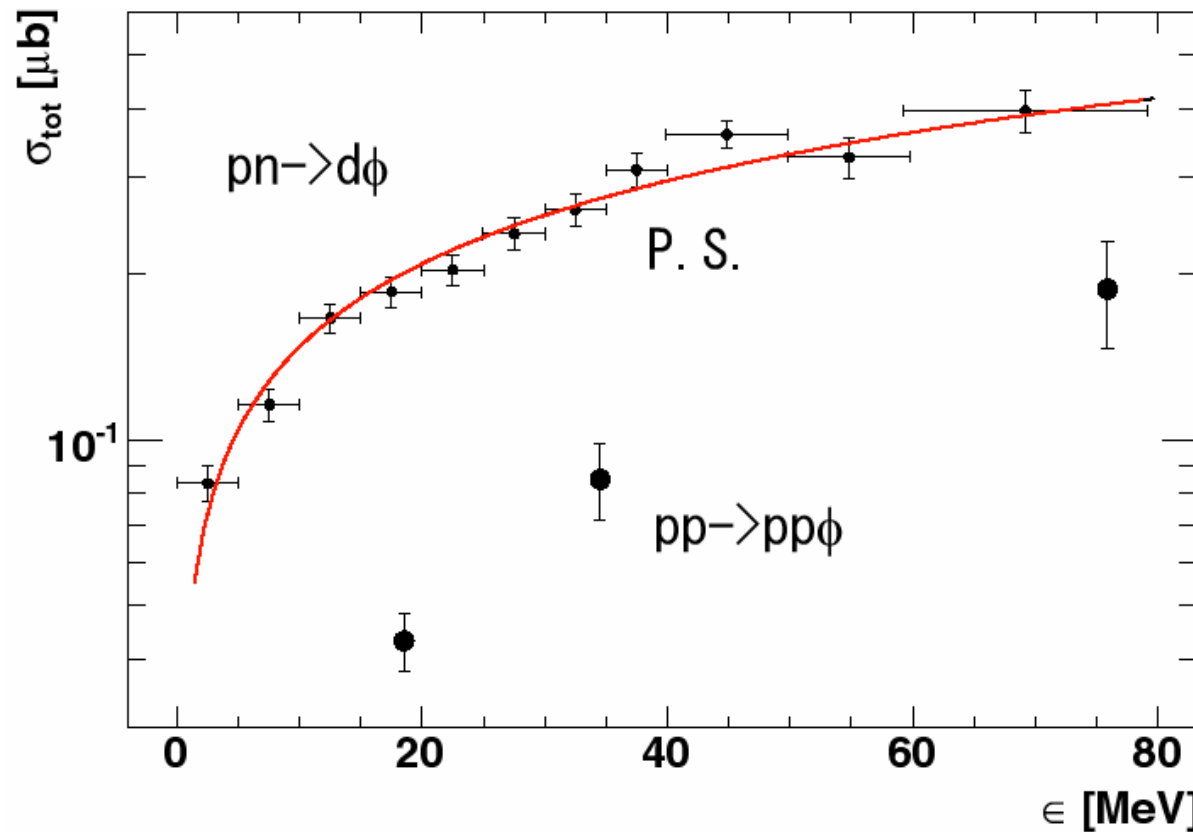
Invariant mass distribution for $pn \rightarrow d\phi$

Spectator model



$$\epsilon(pn) = S^{1/2}[d\phi] - m_\phi - m_d$$

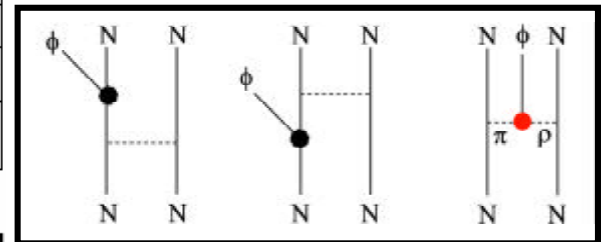
Total cross section for ϕ -meson production in pN collisions



$$s_s(df) \rightarrow s_s(pnf)$$

$$\frac{s(pnf)}{s(ppf)} \approx 2.3 \pm 0.5$$

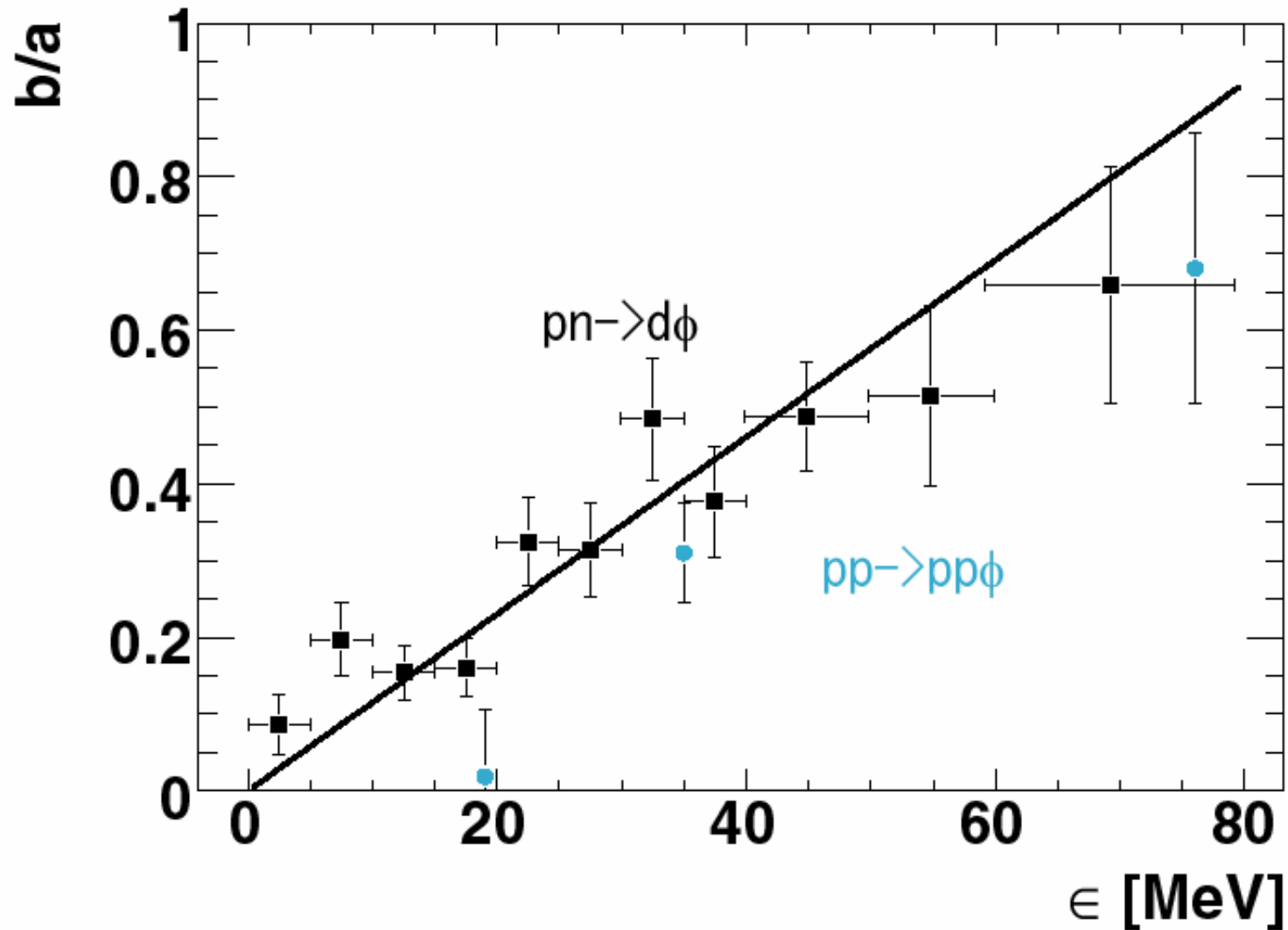
$$\frac{s(pnh)}{s(pph)} \approx 6$$



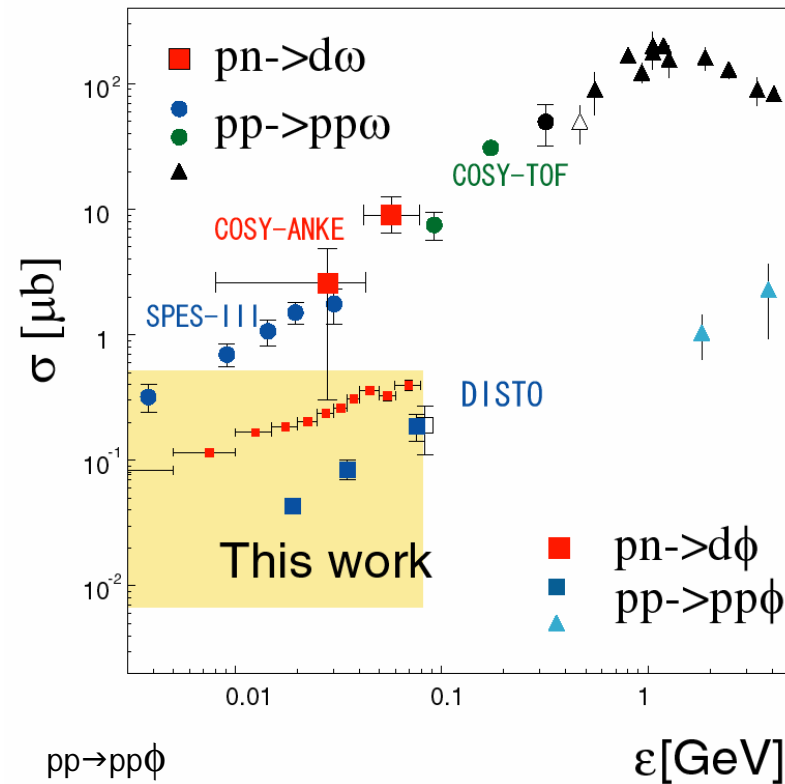
Constructive or destructive?
K. Nakayama, private comuni.

Angular distribution

$$dS / d\Omega_c^k = 3 (a \sin^2 \mathbf{q} + 2b \cos^2 \mathbf{q}) / 8p$$



ϕ/ω -cross section ratio in NN collisions



$pp \rightarrow pp\phi$

F. Balestra et al., Phys. Rev. C63(2001) 024004

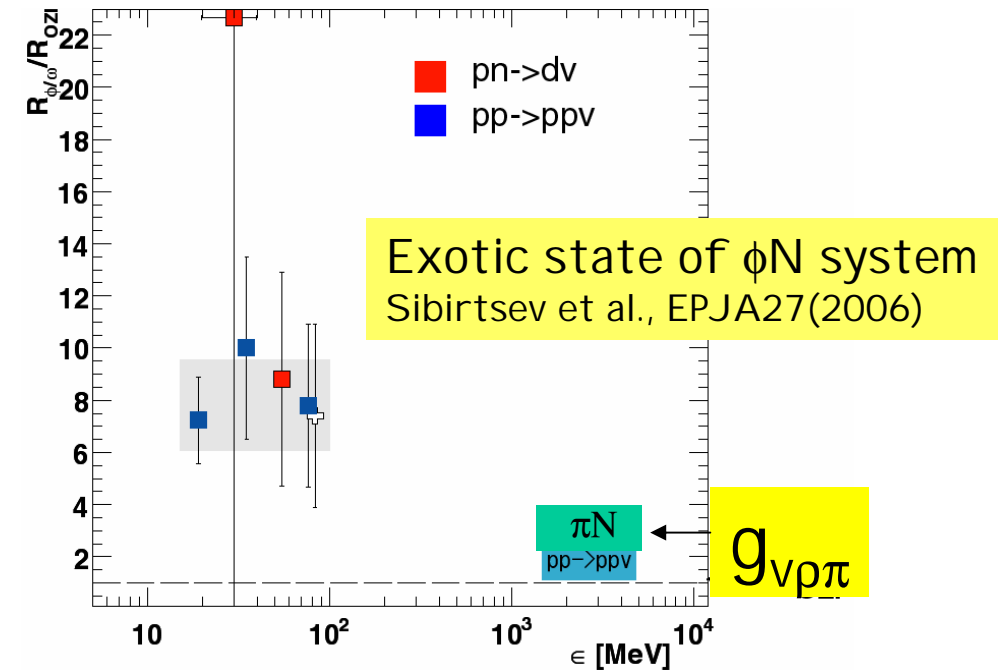
$pp \rightarrow pp\omega$

F.Hibou et al., Phys. Rev. Lett. 83,(1999)492

S.Abd El-Samad et al., Phys Lett. B522,(2001)16

$pn \rightarrow d\phi$

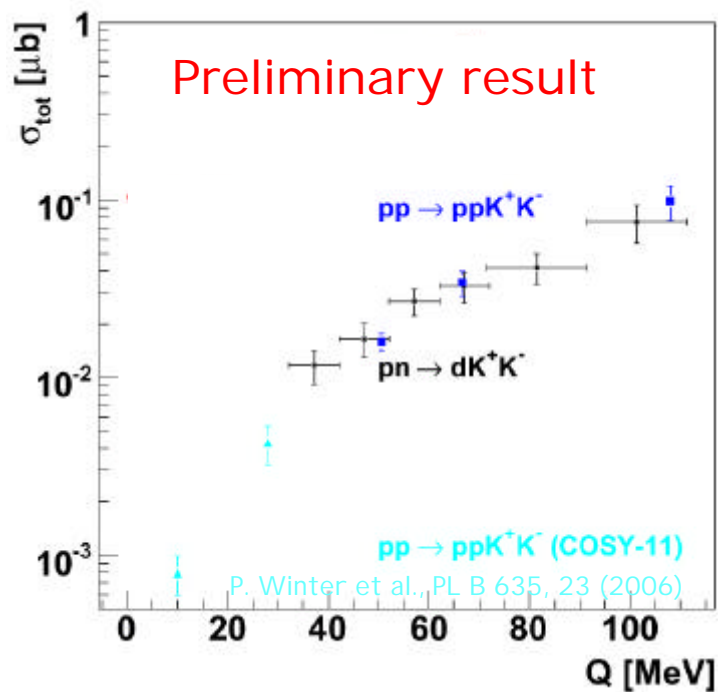
S. Barsov et al., Eur. Phys. J. A21, 521 (2004)



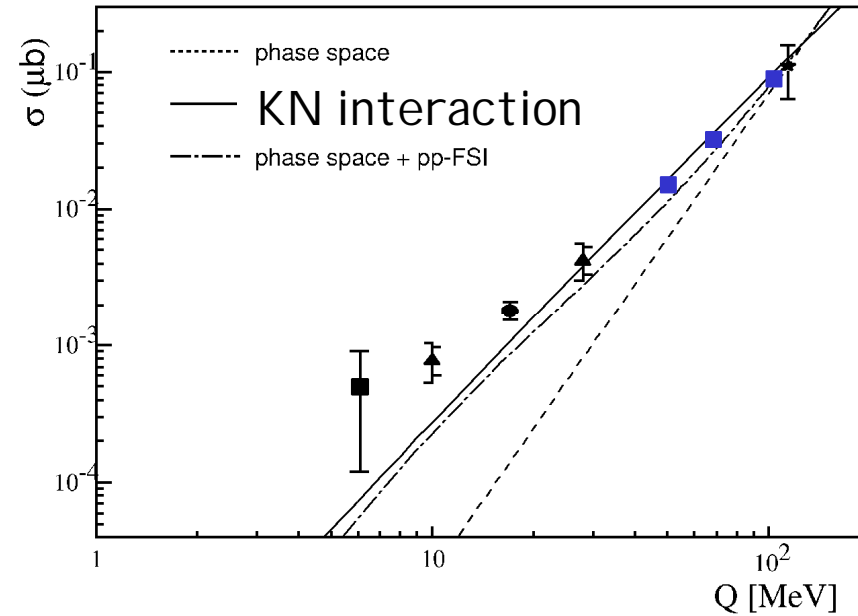
$$R_s(pn) \sim R_t(pp)$$

K⁺K⁻ pair production

- a⁰/f⁰ (980) resonance
- K-p interaction
- K⁻ in few nucleon system

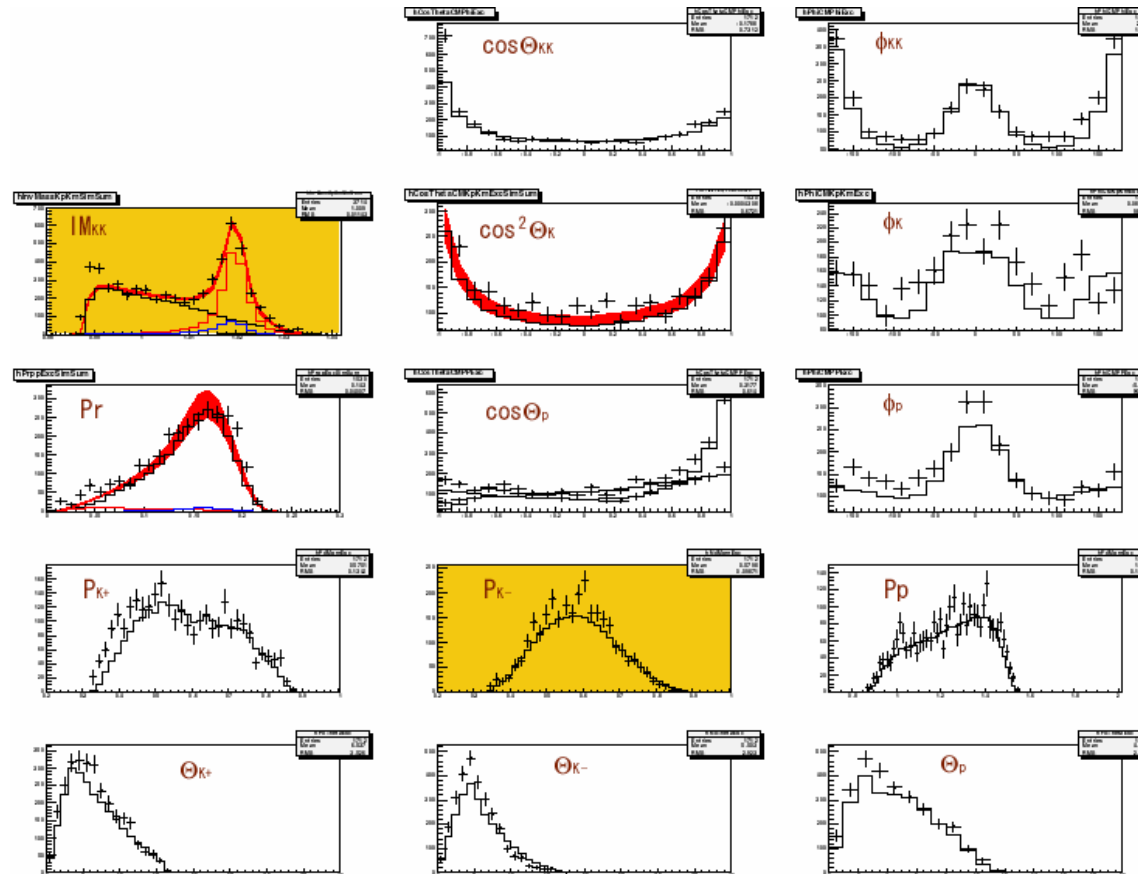


pp → ppK⁺K⁻



- No FSI in pp system
- K-p interaction?
→ Mass distributions

Mass distribution (Preliminary)



a^0/f^0 resonance?
K-p interaction?

Summary

- ϕ – meson production in pp channel at 19, 35 and 76 MeV.

$${}^3P_1 \rightarrow {}^1S_0 \text{ s}$$

$$R(pp) = 8 R_{OZI}$$

- First data of $\sigma(pn \rightarrow d\phi)$ at $\varepsilon = 0 - 80$ MeV.

$$\sigma(pn)/\sigma(pp) = 2.3 \pm 0.5$$

Φ meson p-wave

$$R_s(pn) \sim R_t(pp)$$

- Non-resonant K^+K^- pair production

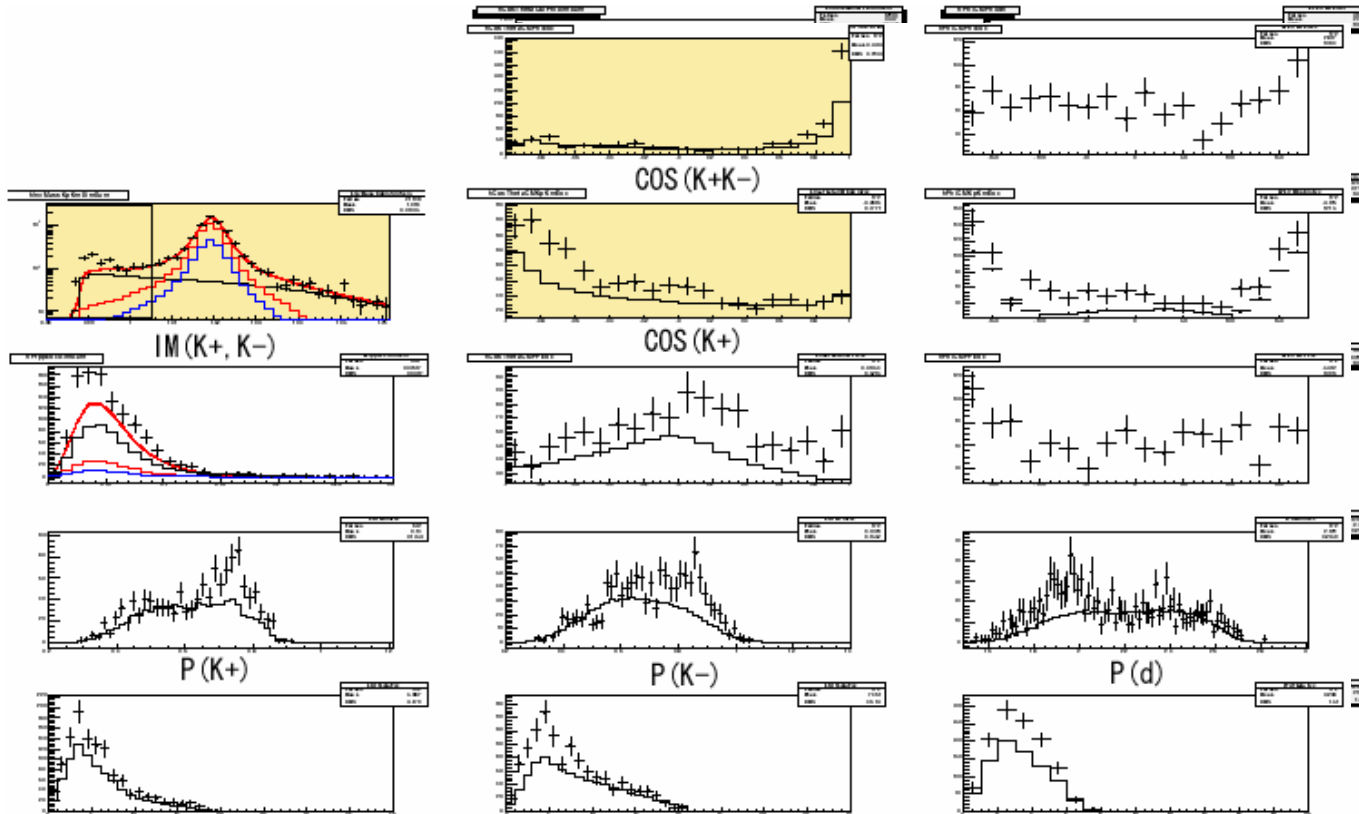
$$\sigma(pn)/\sigma(pp) \sim 1$$

no FSI effect in pp system

K-p interaction

$a^0/f^0(980)$, K-pp system

pn → dK⁺ K⁻



		$I(\bar{K}K)$		I_{l_q}	
3S_1	→	3S_1	s	0	Ss
1P_1	→	3S_1	p	0	Sp
3P_0	→	3S_1	p	1	Tp^0
3P_1	→	3S_1	p	1	Tp^1
3P_2	→	3S_1	p	1	Tp^2

$$\frac{d\sigma}{d\Omega_q} = |Ss|^2 + (|Sp|^2 + |Tp^1|^2 + |Tp^2|^2)/3$$

$$+ 2\Re(SsTp^{1*} + \sqrt{5/3} SsTp^{2*})/3 P_1(\cos\theta_q)$$

$$+ \sqrt{5}(-|Sp|^2 + |Tp^1|^2/2 + 3\sqrt{3/5} \Re(Tp^1Tp^{2*}) + 0.6996 |Tp^2|^2)/15 P_2(\cos\theta_q)$$

(KK)_{l=0,1} contribution

Normalization

- ✓ Target density measurement by frequency shift of COSY
- ✓ pp and pd scattering
- Systematical uncertainty 6%

