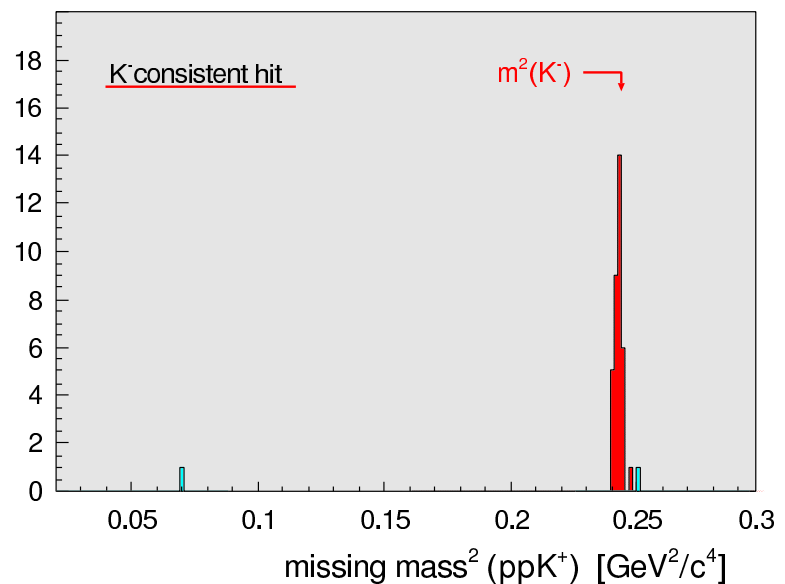
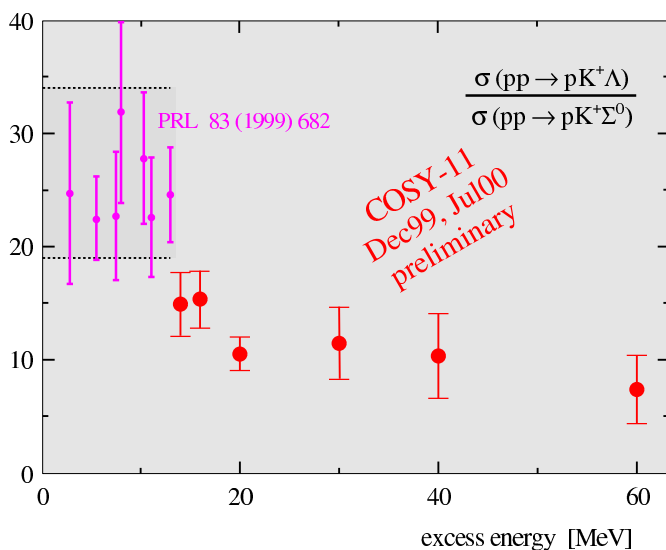


# Strangeness-Produktion in Schwellennähe an COSY-11

Magnus Wolke  
 Institut für Kernphysik I  
 Forschungszentrum Jülich  
 für die  
 COSY-11 Kollaboration



Arbeitstreffen "Hadronen und Kerne"  
 Pommersfelden  
 24.-28. September 2001



# Strangeness-Produktion in Schwellennähe an COSY-11

- **Studien zu  $\eta^-$  und  $\eta'$  im Proton-Proton Stoß**

Energieabhängigkeit des totalen Wirkungsquerschnitts

Zugang zur Meson-Nukleon Wechselwirkung

Quasifreie Produktion am Neutron

- **Exklusive Kaon-Hyperon-Produktionsexperimente**

$\Lambda/\Sigma^0$  Produktionsverhältnis

Theoretische Studien und physikalische Interpretation

Gegenwart und Zukunft

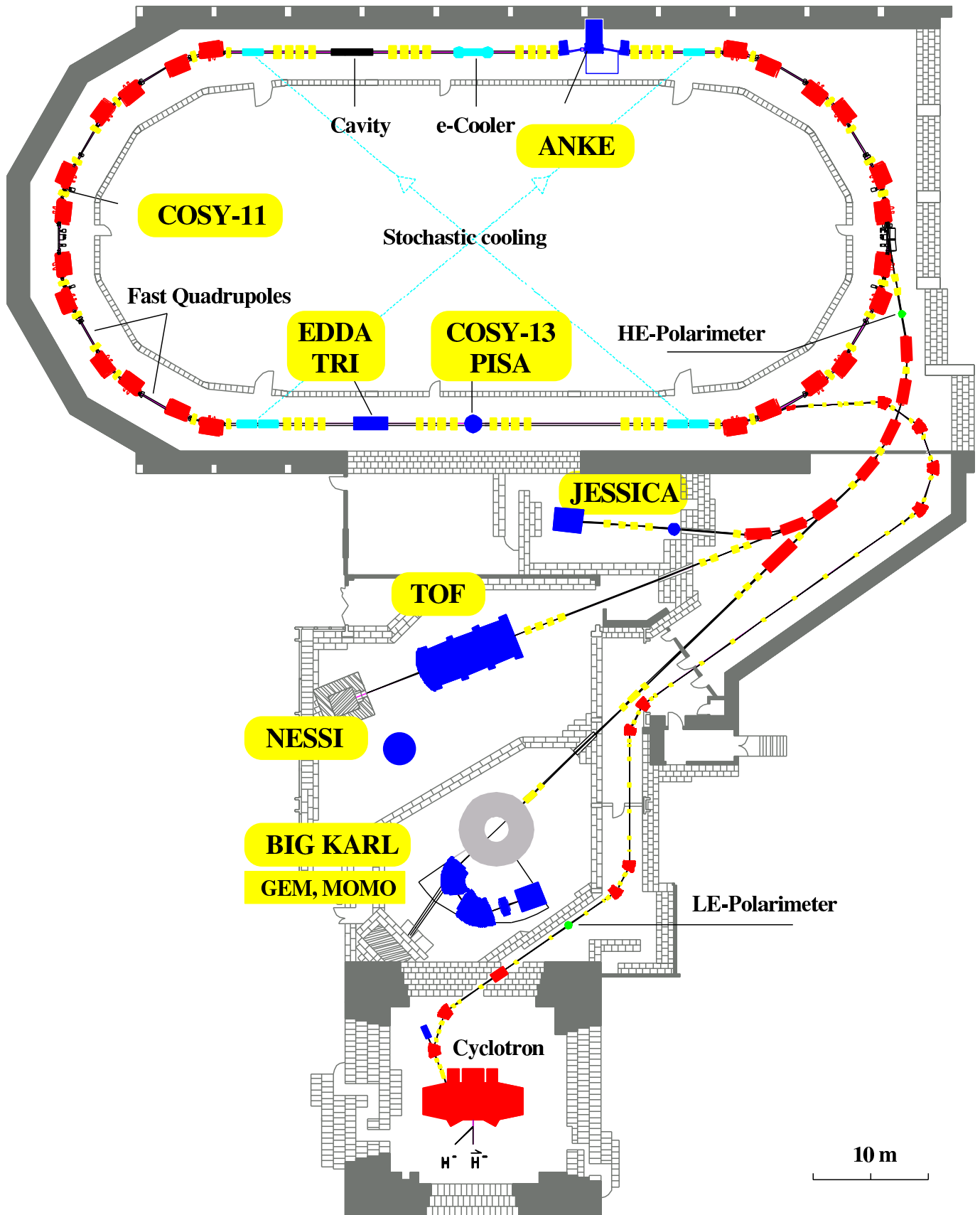
- **Elementare Strangeness-Dissoziation in den  $K^+K^-$ -Kanal**

Physikalische Motivation

Ergebnisse und experimentelles Programm

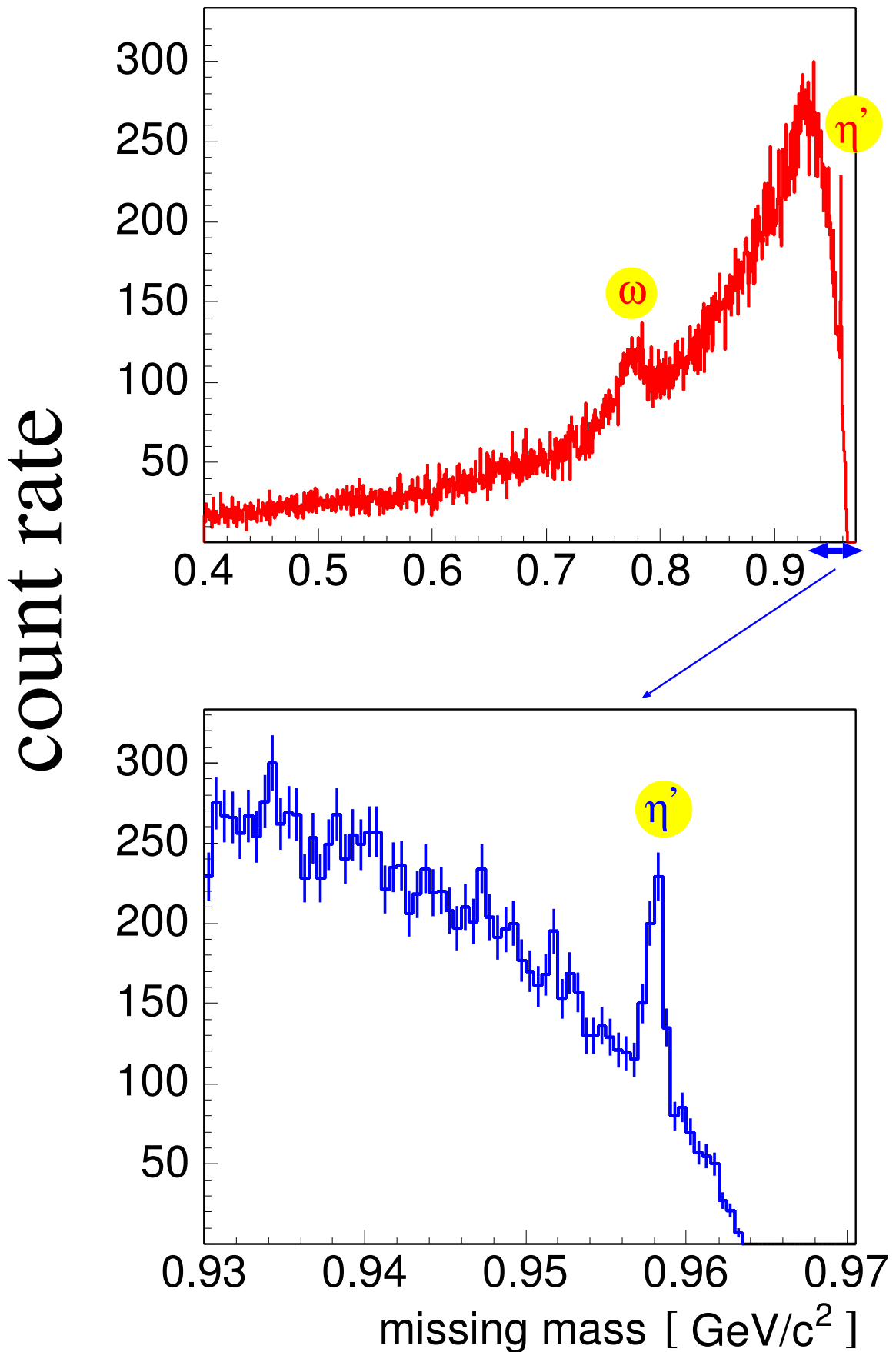
*Arbeitstreffen  
"Hadronen und Kerne"  
Pommersfelden, 28. September 2001*

# COoler-SYnchrotron



**$pp \rightarrow pp X$**

$$Q_{(X=\eta')} = 6 \text{ MeV} \iff P_{\text{beam}} = 3.227 \text{ GeV}/c$$



$$\begin{aligned}
\sigma_T (pp \rightarrow ppX) &= C \frac{(m_p + m_X)^2}{(2m_p + m_X)^{5/2}} \\
&\times \frac{\sqrt{m_X}}{(m_p m_X + m_\pi^2)^2} \\
&\times |f(\pi^0 p \rightarrow pX)|^2 \\
&\times \frac{Q^2}{\varepsilon} \frac{1}{(1 + \sqrt{1 + Q/\varepsilon})^2}
\end{aligned}$$

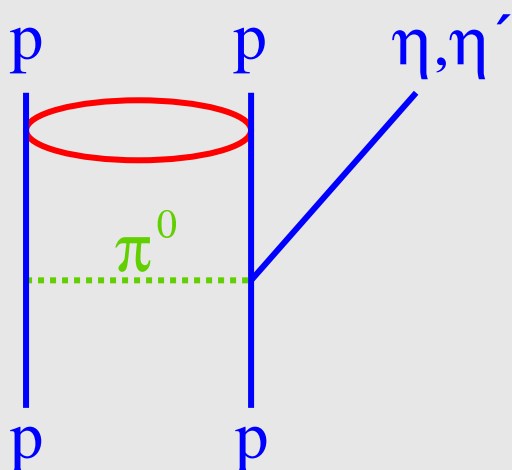
$X = \eta, \eta'$

$\varepsilon = 0.45 \text{ MeV}$

$C = \text{constant, independent of } X \text{ parameters}$

$$|f(\pi^0 p \rightarrow p\eta)|^2 = 365 \pm 30 \mu\text{b}$$

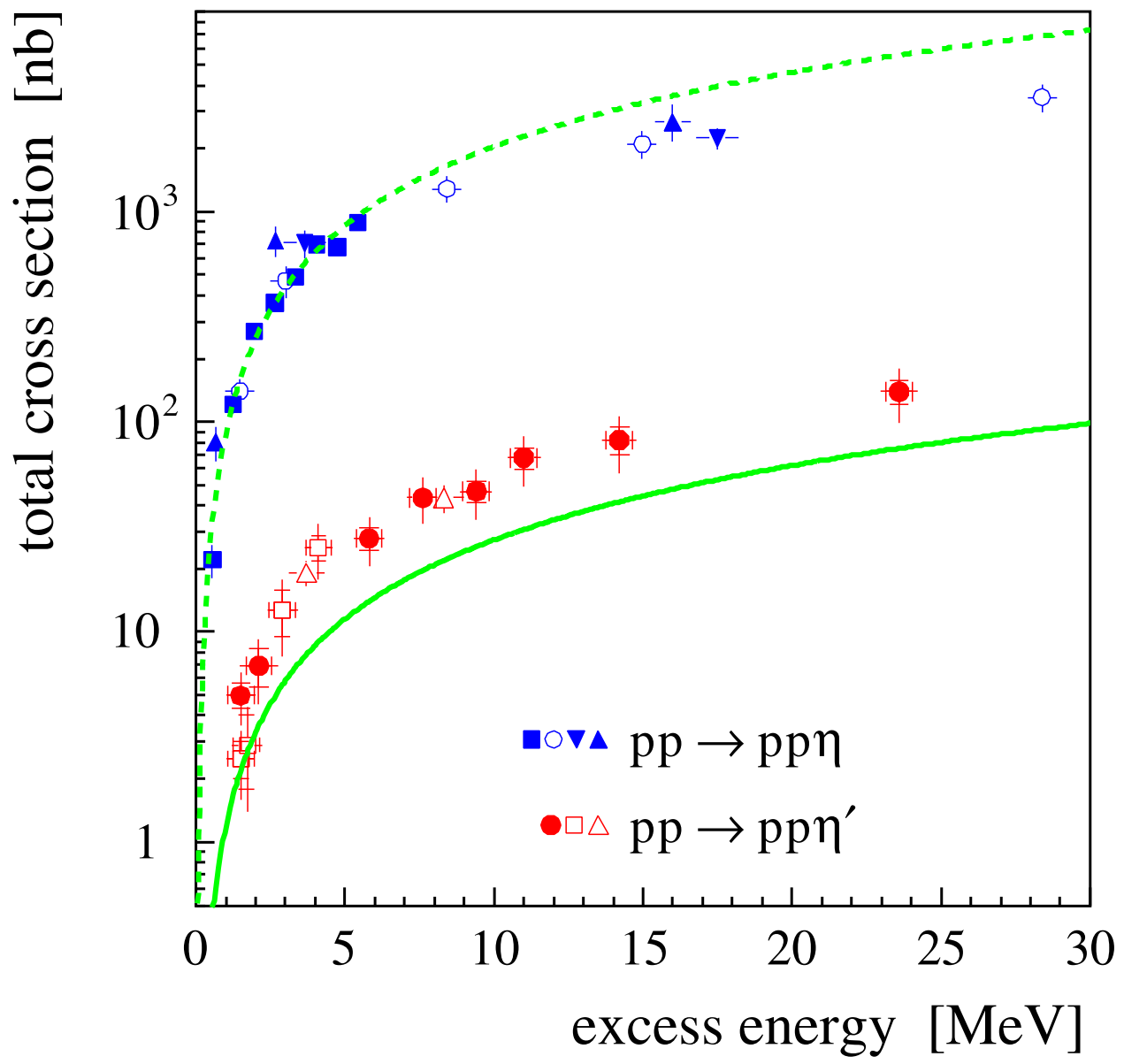
$$|f(\pi^0 p \rightarrow p\eta')|^2 = 10 \pm 1 \mu\text{b}$$

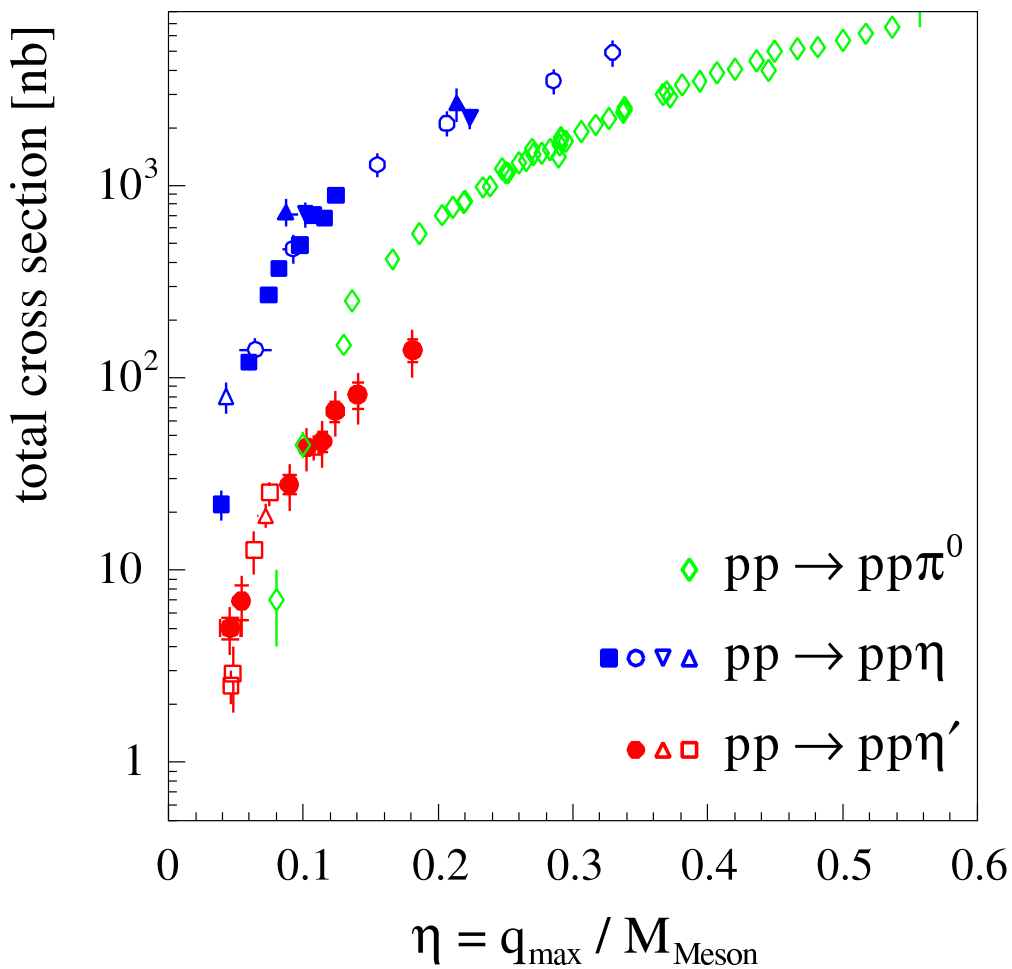
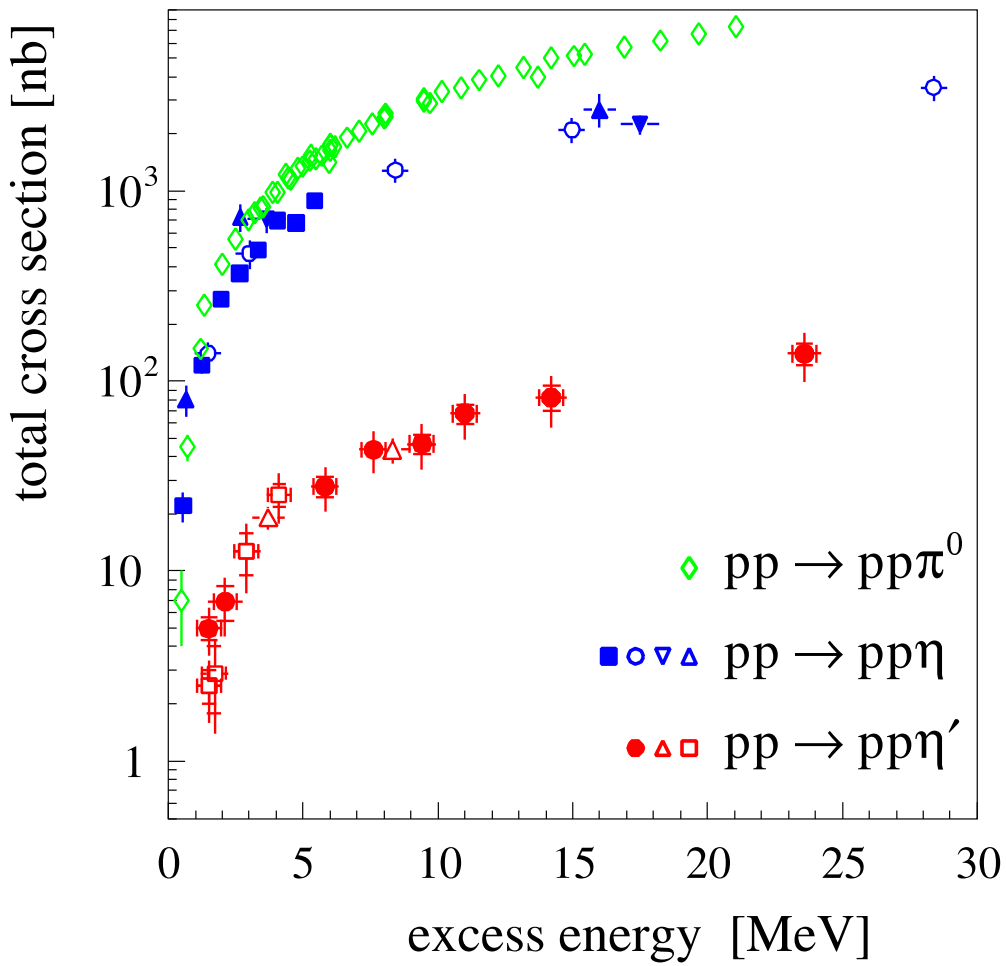


J.-F. Germond, C. Wilkin,  
Nucl. Phys. A518 (1990) 308

G. Fäldt, C. Wilkin,  
Phys. Lett. B382 (1996) 209

F. Hibou et al.,  
Phys. Lett. B438 (1998) 41





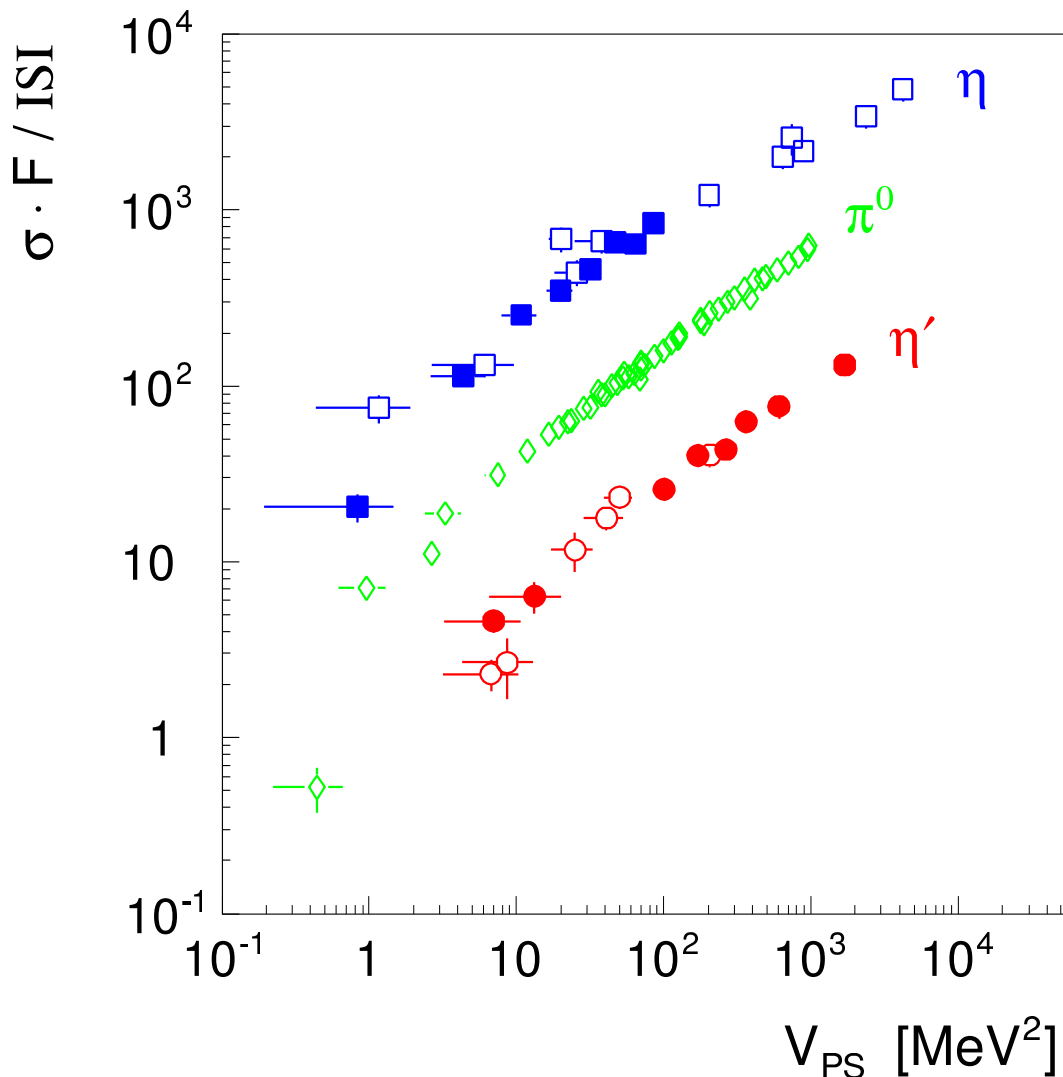
# pp → ppX Close to Threshold

## Phase Space Dependence

$$\sigma_{pp \rightarrow ppX} = \frac{1}{F} \int dV_{PS} |M_{pp \rightarrow ppX}|^2$$

$$F = 2(2\pi)^5 \sqrt{s(s - 4m_p^2)}$$

$$|M_{pp \rightarrow ppX}| \approx |M_0| \cdot |M_{FSI}| \cdot ISI$$



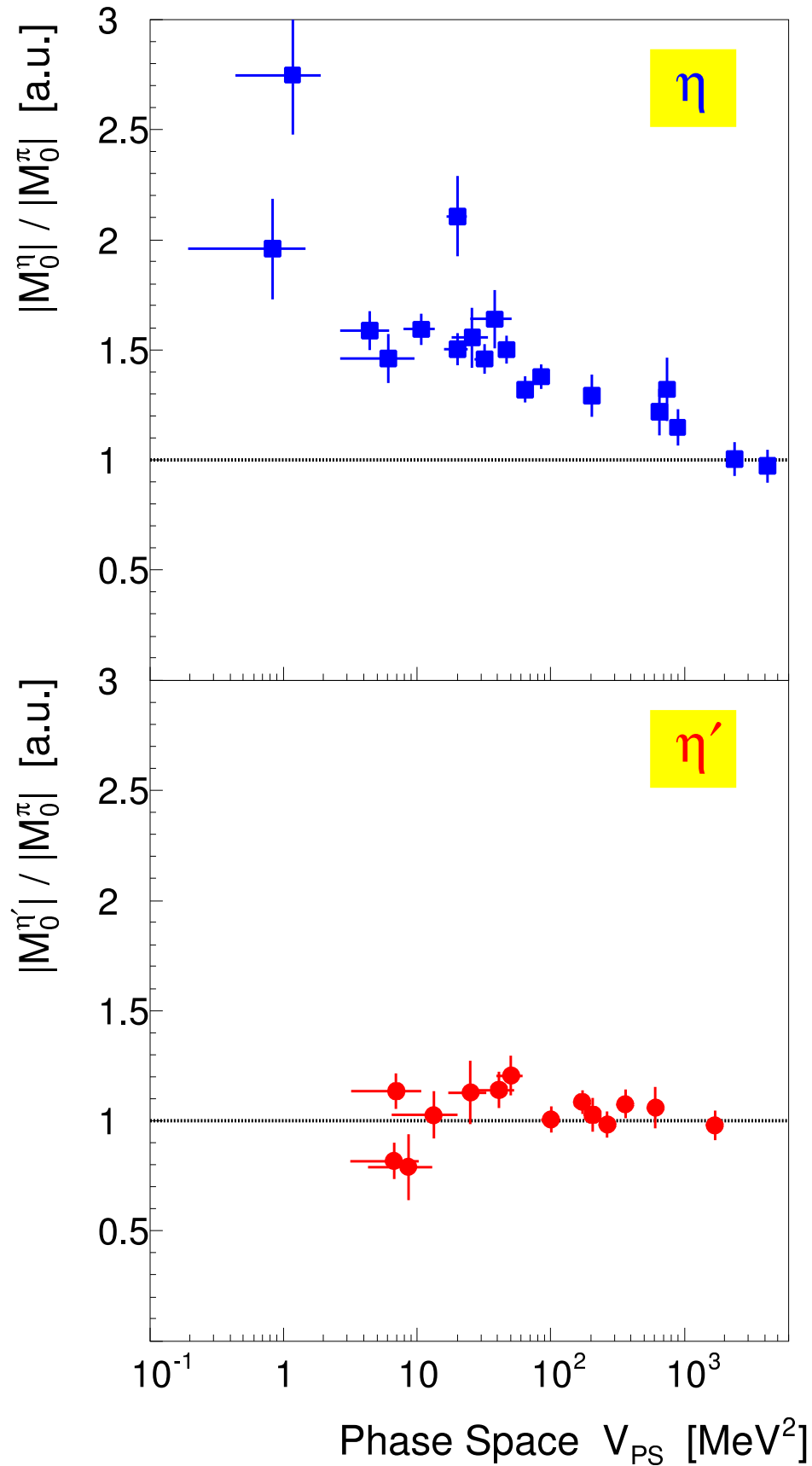
■	<b>COSY-11</b>	Phys. Lett. B474 (2000) 182	◇	<b>IUCF</b>	Phys. Rev. Lett. 65 (1990) 2846
□	<b>SPES3</b>	Phys. Lett. B 438 (1998) 41		<b>CE-01, CE-23</b>	Nucl. Phys. A 539 (1992) 633
		Phys. Rev. D 48 (1993) R2969		<b>CELSIUS</b>	Phys. Lett. B 356 (1995) 8
	<b>CELSIUS</b>	Phys. Lett. B 366 (1996) 39	●	<b>COSY-11</b>	Phys. Lett. B 474 (2000) 416
	<b>PINOT</b>	Phys. Lett. B 322 (1994) 270		○	Phys. Rev. Lett. 80 (1998) 41
				<b>SPES3</b>	Phys. Lett. B 438 (1998) 41



# $\eta$ and $\eta'$ Production Amplitude

P.Moskal et al.,  
Phys. Lett. B 482 (2000) 356

Normalization to  $\pi^0$  Production



**Kurzreichweitige Wechselwirkung ( $\sim 0.2$  fm)  
der Nukleon-Nukleon Streuung  
produziert Glue,  
das sich zu dem Endzustand  $\eta'$  entwickelt.**

Glue "flavour-blind"

→ bei Dominanz im Reaktionsmechanismus...  
...wird der Verlauf der Reaktionen

$pp \rightarrow pp\eta'$  und  $pn \rightarrow pn\eta'$  nach gleichem  
Muster geschehen

$$\text{CELSIUS: } R(\eta) = \frac{\sigma(pn \rightarrow pn\eta)}{\sigma(pp \rightarrow pp\eta)} \approx 6.5 \quad \text{energie-  
unabhängig}$$

→ starke Isovektor-  
Austauschkomponenten

$$\text{COSY: } R(\eta') = \frac{\sigma(pn \rightarrow pn\eta')}{\sigma(pp \rightarrow pp\eta')} = \frac{?}{\text{gemessen}}$$

### Szenario:

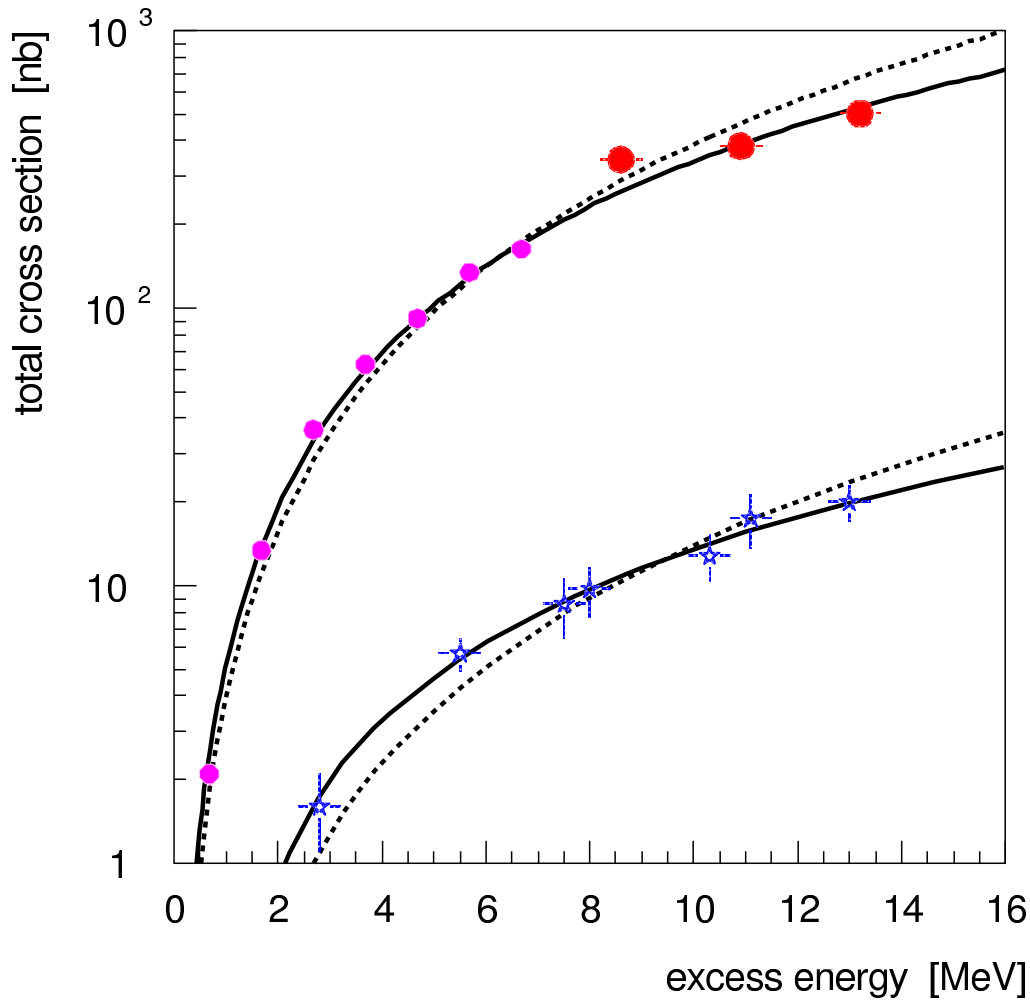
a) {Struktur  $\eta'$ } = {Struktur  $\eta$ } bezogen auf gluonischen Anteil:

→  $R(\eta') = R(\eta)$

b)  $\eta'$  über gluon-induzierten Prozess erzeugt:

→  $R(\eta') \rightarrow \text{Eins}$  an der Schwelle

# Hyperon Production close to Threshold at COSY-11



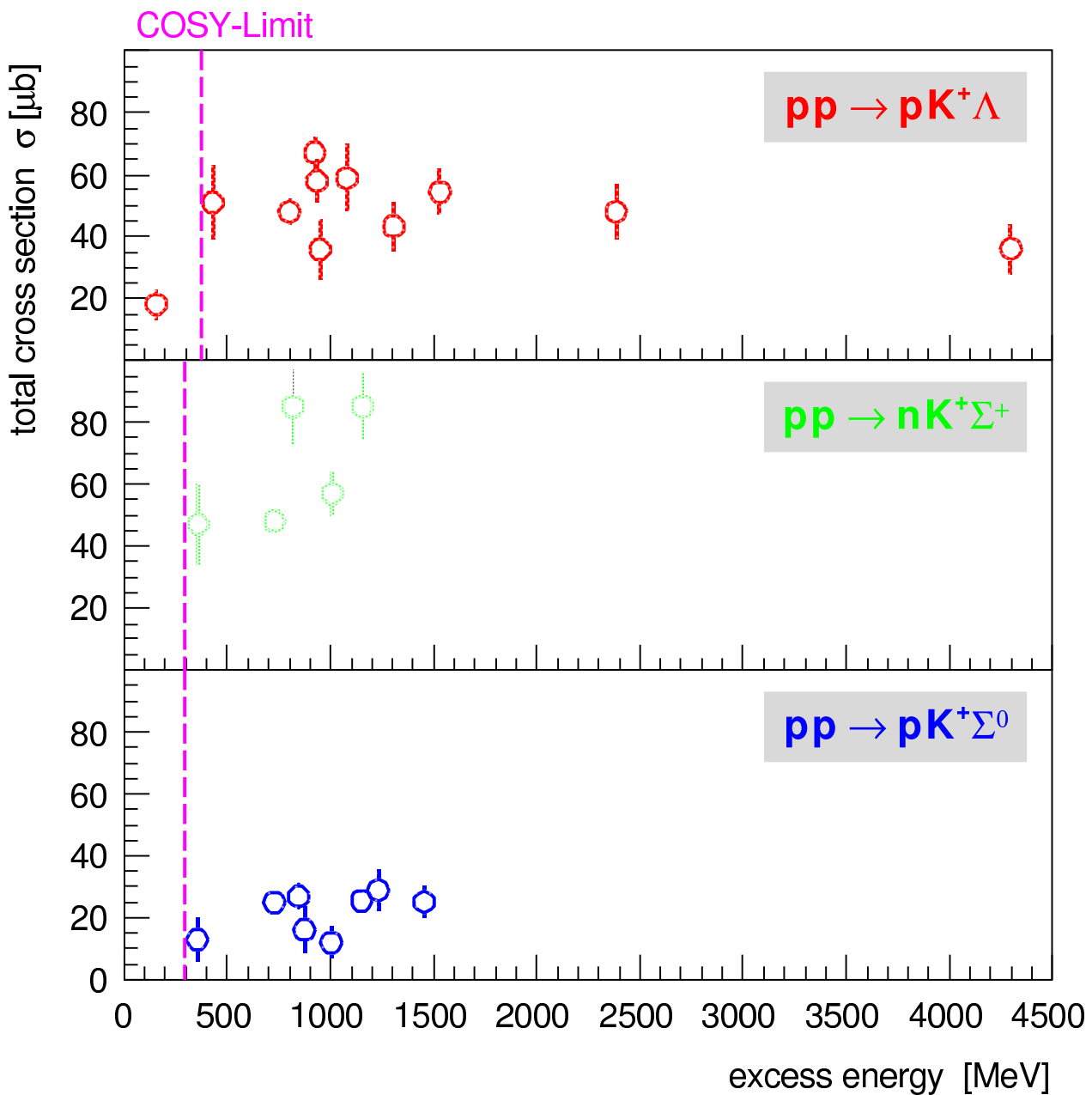
$$\frac{\sigma_T (pp \rightarrow p K^+ \Lambda)}{\sigma_T (pp \rightarrow p K^+ \Sigma^0)} = 28_{-9}^{+6}$$

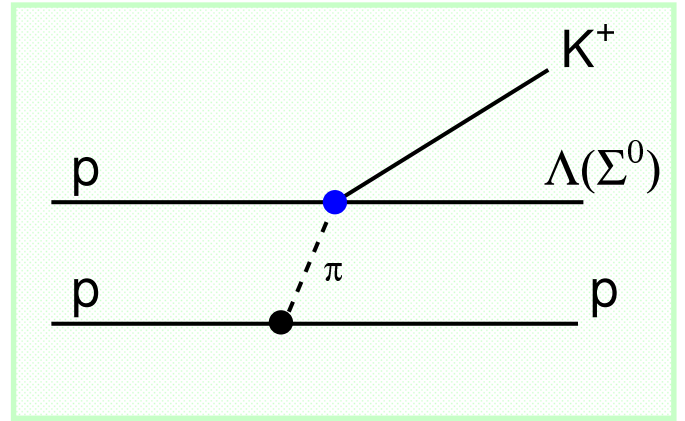
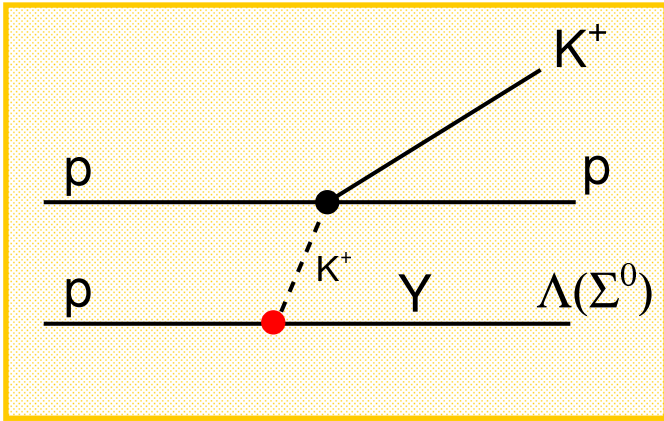
S.Sewerin et al.,  
Phys. Rev. Lett. 83 (1999) 682

# Hyperon Production in Proton-Proton Scattering

V.Flaminio, W.G.Moorhead,  
D.R.O.Morrison, N.Rivoire,  
*Compilation of Cross Sections,*  
CERN-HERA 84-01 (1984)

## High Energy Data





$\Downarrow$  SU(6)

$\pi^- p \rightarrow K^0 \Lambda(\Sigma^0)$   $\Downarrow$

$$27 \quad \leftarrow \frac{pp \rightarrow pK^+\Lambda}{pp \rightarrow pK^+\Sigma^0} \rightarrow \quad 0.4$$

$\frac{\Lambda}{\Sigma^0}$  ratio of production can not be explained by a dominant  $\pi^0$ -exchange

- inclusive  $K^+$  data in pp collisions (SPES4)

possible explanation:  $\Sigma N \rightarrow \Lambda N$  conversion

$\Sigma$  yield must be larger than from  $K^+$ -exchange with SU(6) coupling

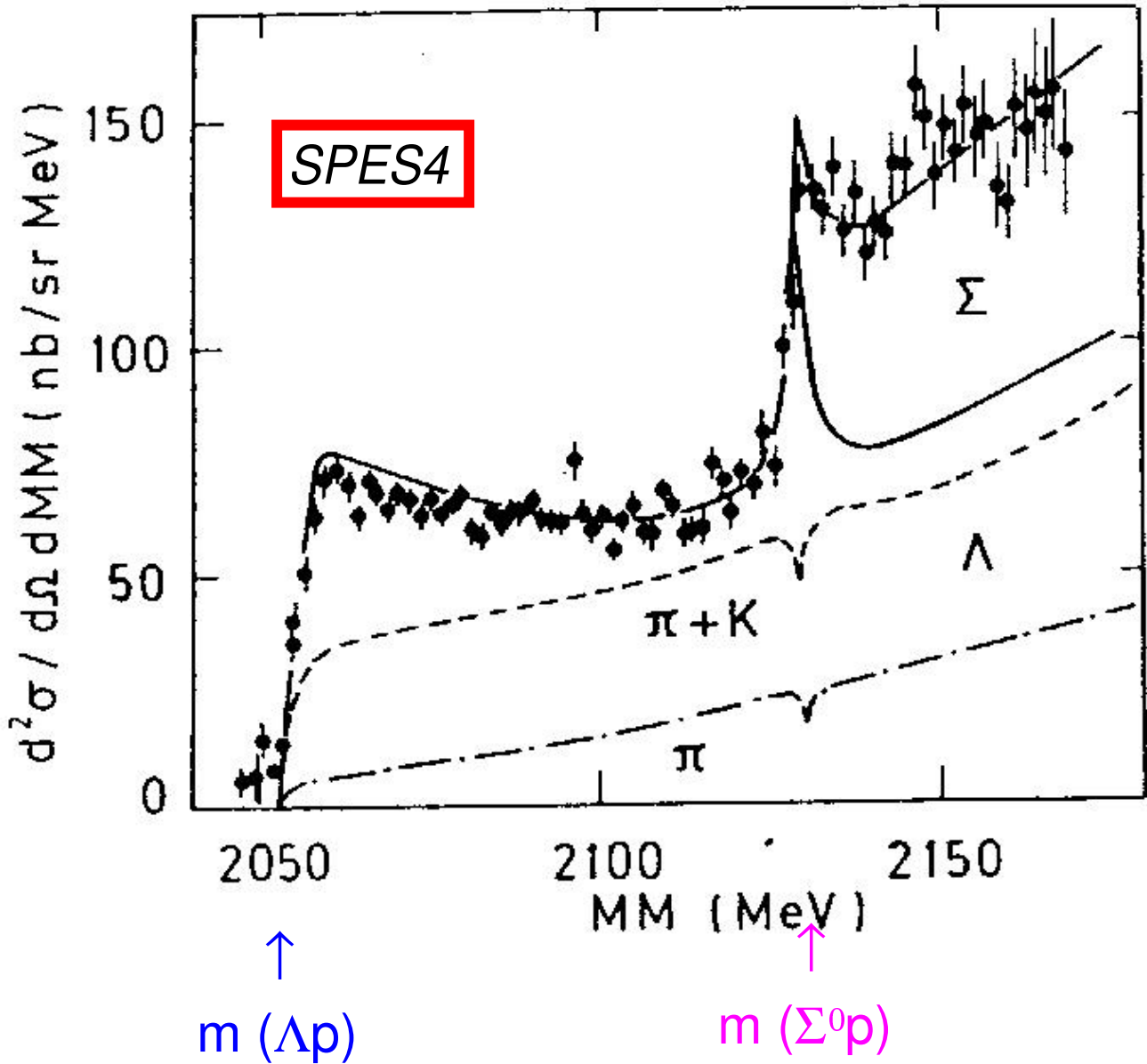
...in qualitative agreement with

- $K^-$  absorption on deuterium (BNL 1969)
- "cusp"-effect observed at COSY-TOF

$p p \rightarrow K^+ Y N$

inclusive cross sections

R. Siebert et al.,  
Nucl. Phys. A567 (1994) 819



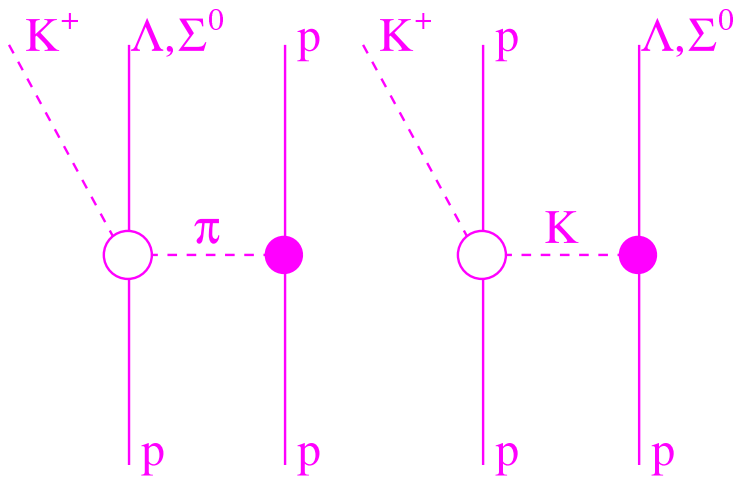
J. M. Laget,  
Phys. Lett. B259 (1991) 24

$(\pi + K)$ -exchange  
YN-final state interaction

# The $pp \rightarrow pK^+\Lambda/\Sigma^0$ Ratio: Energy Dependence

A.Sibirtsev, K.Tsushima, W.Cassing, A.W.Thomas  
e-Print Archive nucl-th/0004022

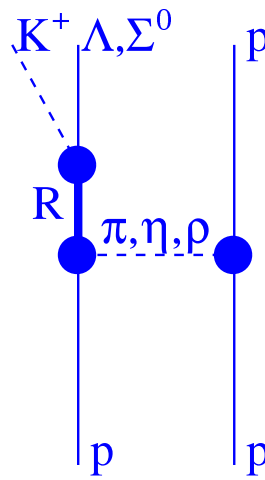
## Boson Exchange Model



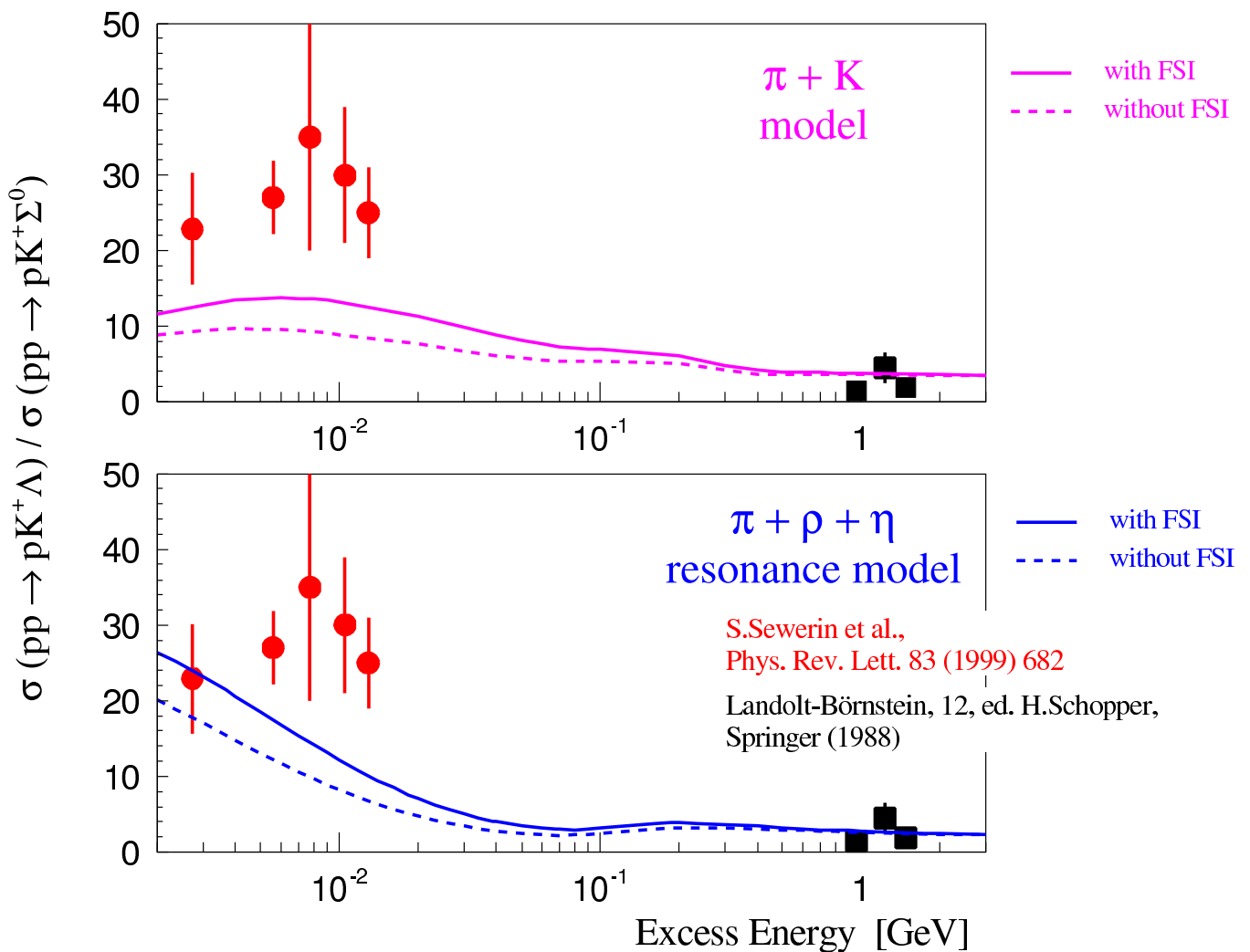
A.Sibirtsev, W.Cassing,  
e-Print Archive nucl-th/9802019

and

## Resonance Model Predictions

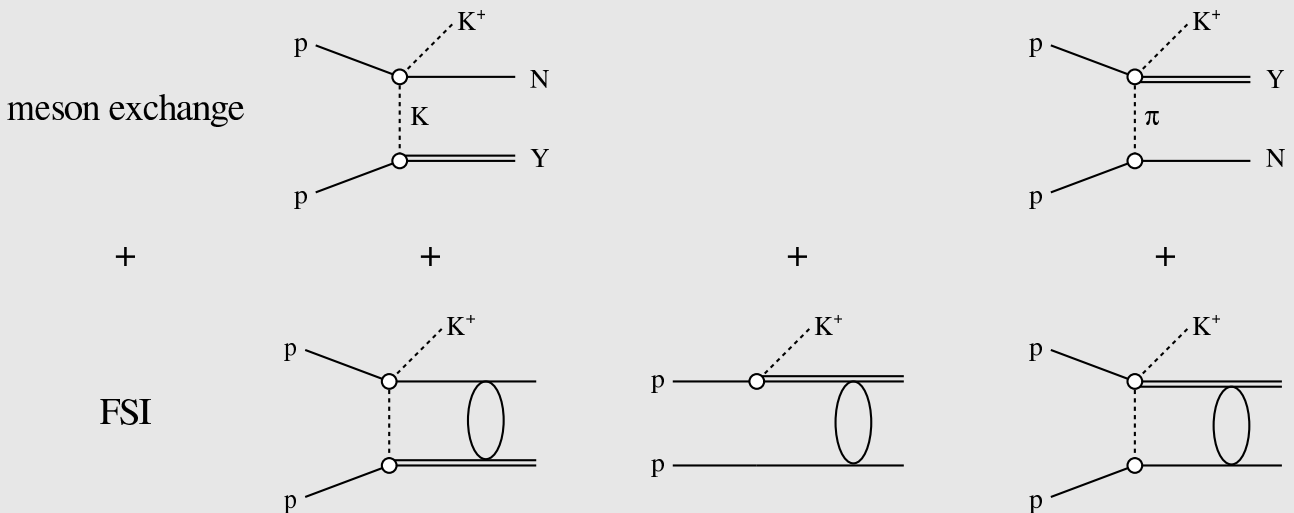
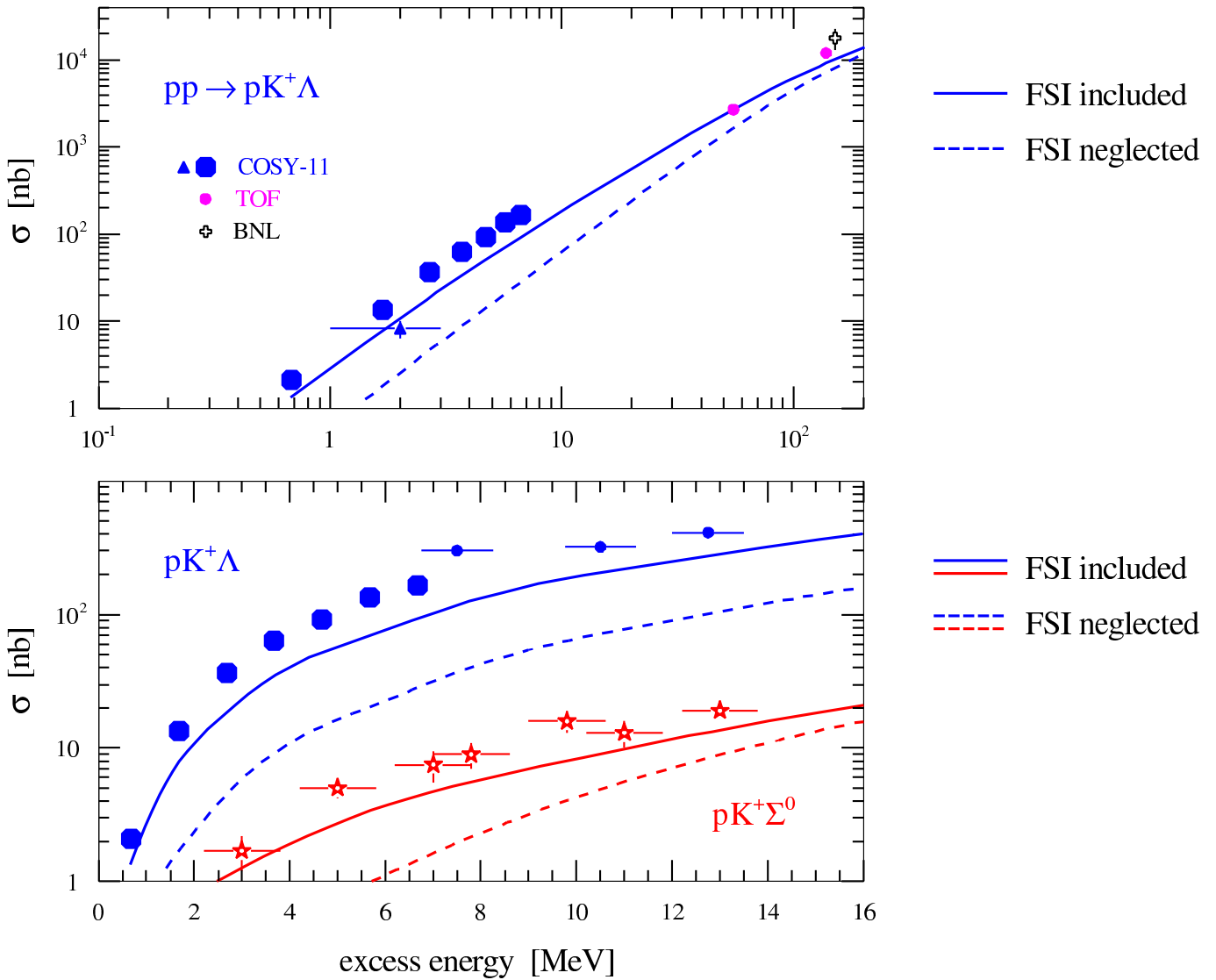


K.Tsushima, A.Sibirtsev, A.W.Thomas, G.Q.Li,  
Phys. Rev. C59 (1999) 369



# Pion and Kaon Exchange Model

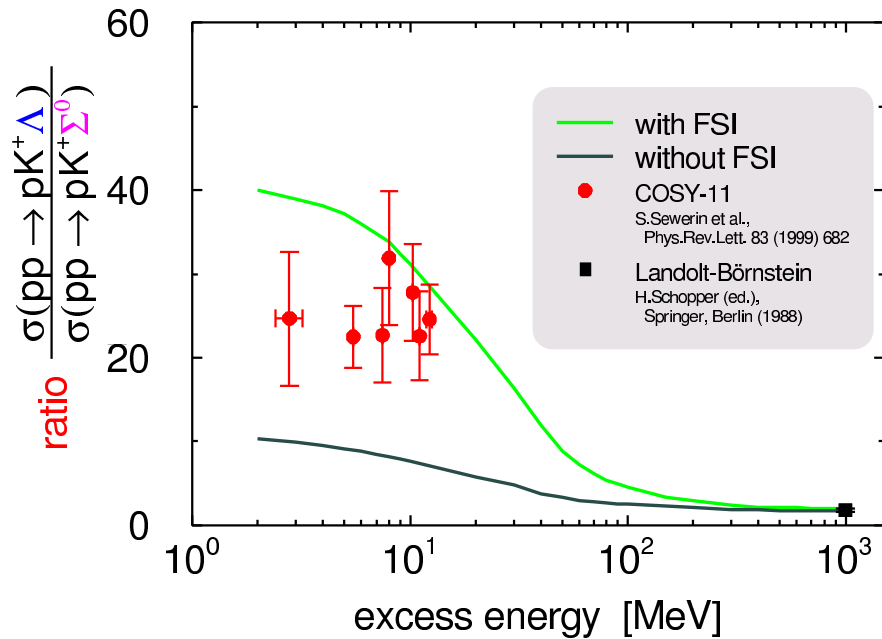
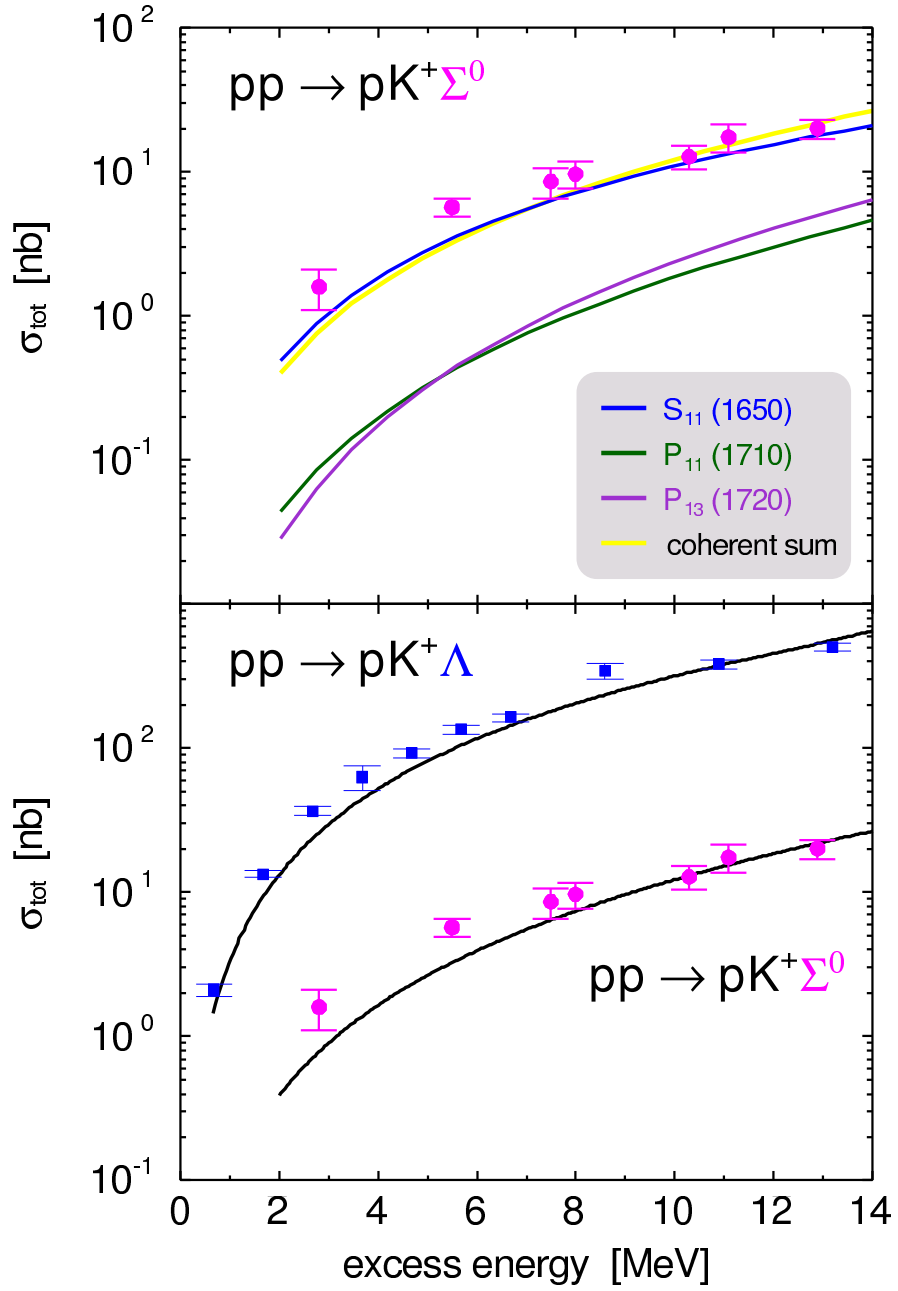
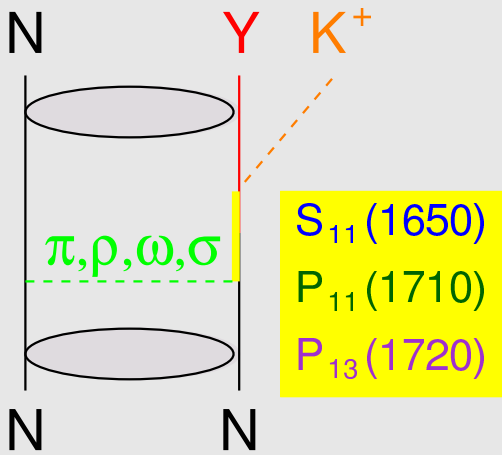
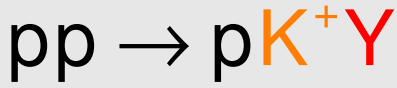
J.-M. Laget,  
 HYP2000,  
 Torino, 23-27 October, 2000  
 ArXiv: hep-ph/0101047





# Effective Lagrangian Approach

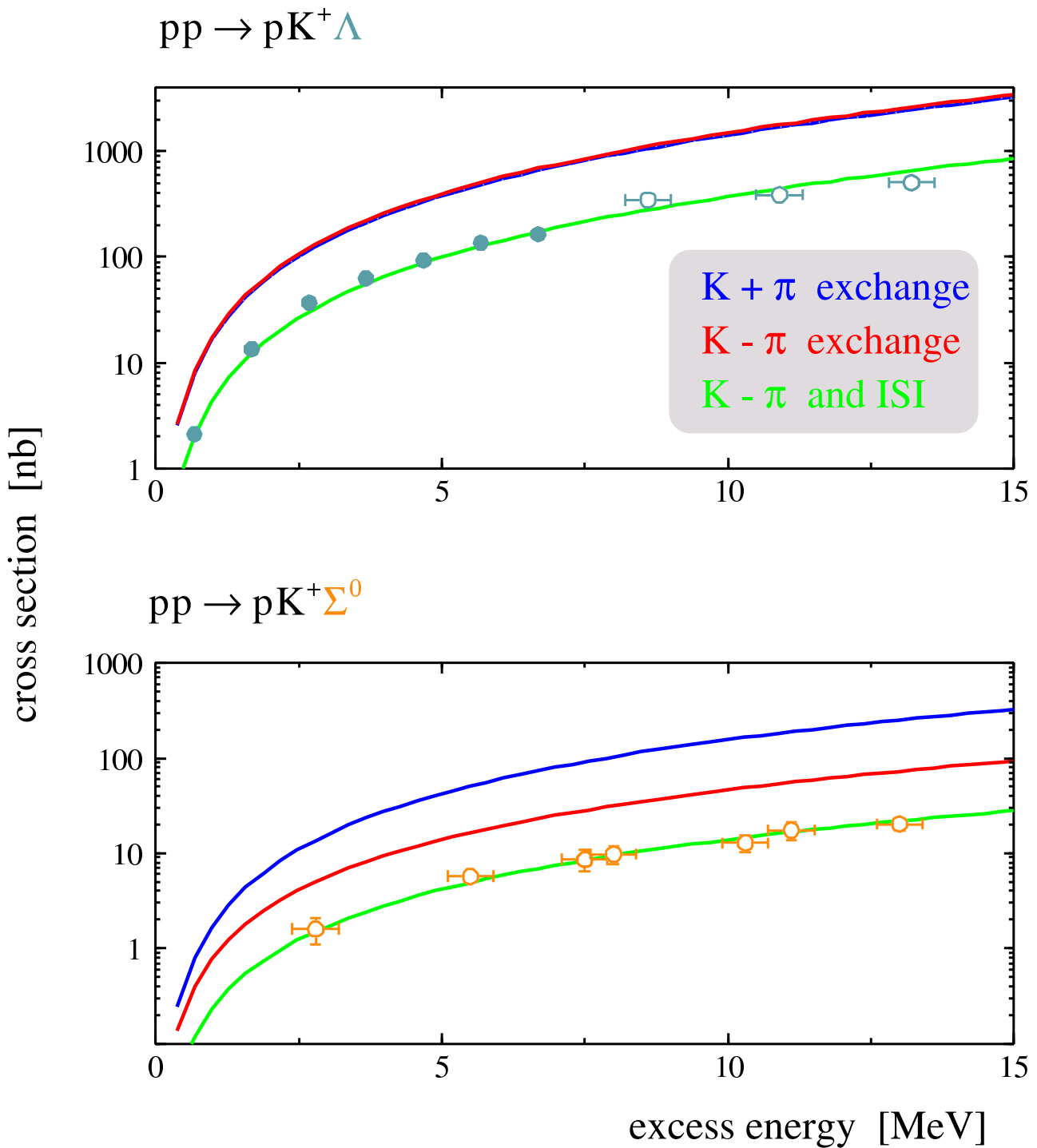
R. Shyam, G. Penner, U. Mosel  
 Phys. Rev. C 63 (2001) 022202





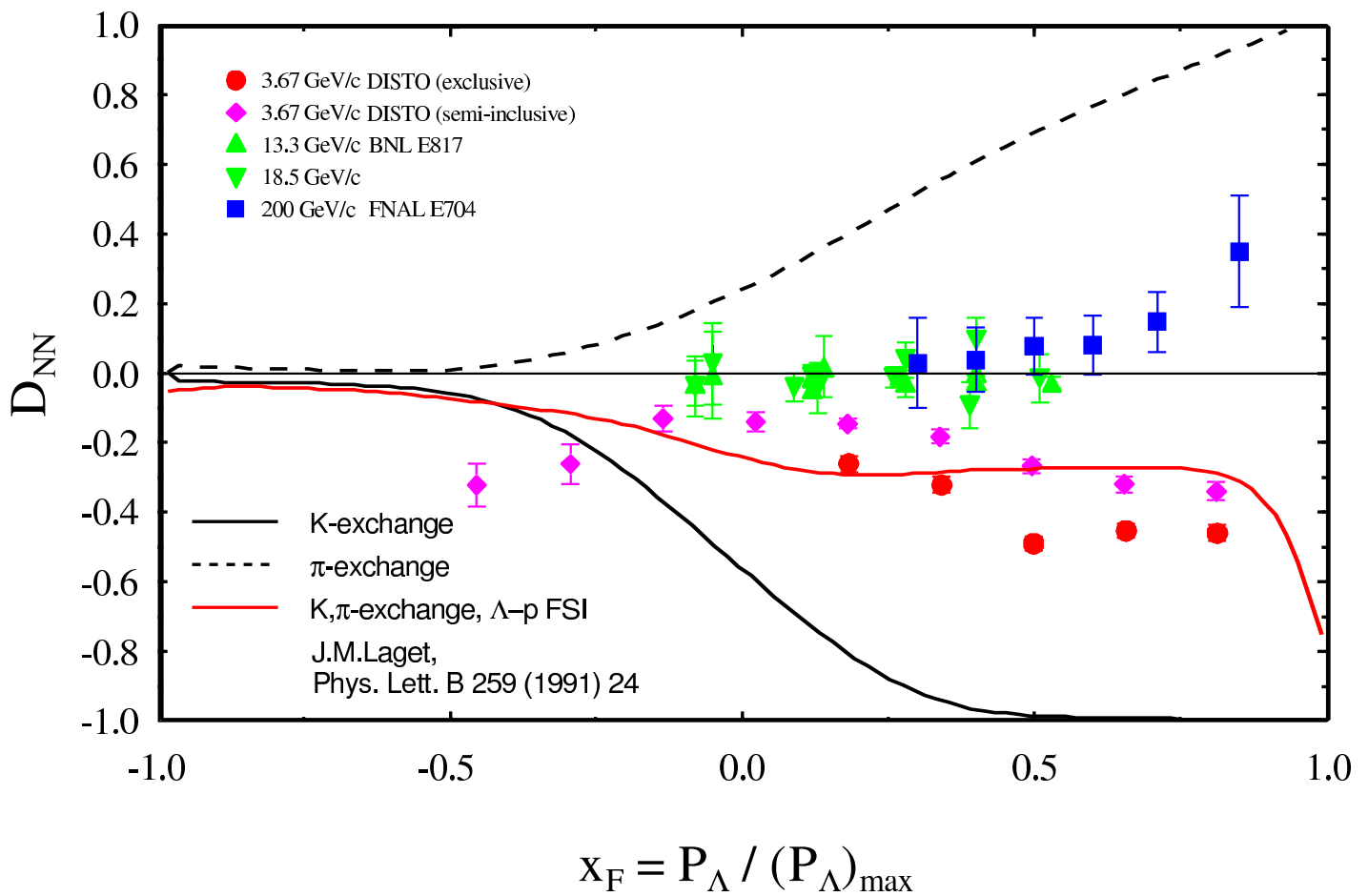
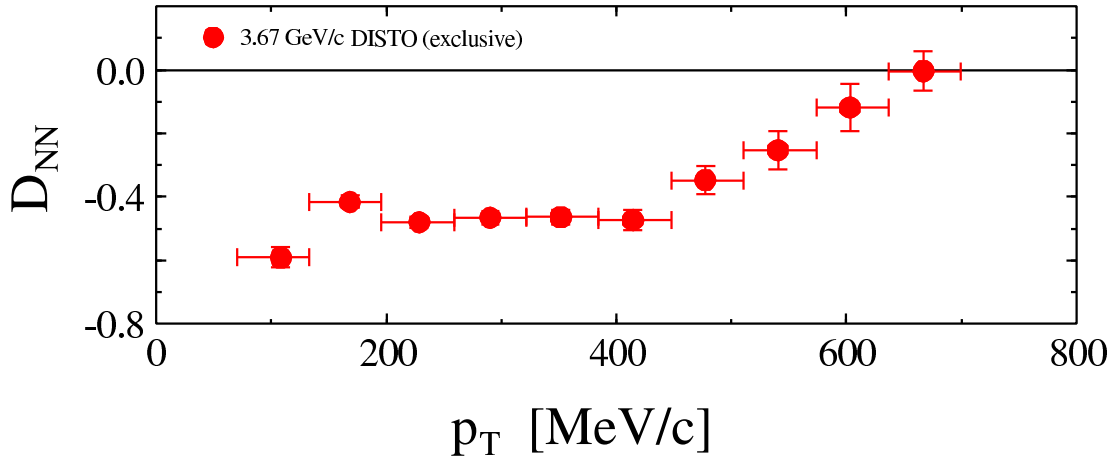
## Jülich Meson Exchange Model

A.M. Gasparian, J. Haidenbauer,  
C. Hanhart, L. Kondratyuk, J. Speth,  
Phys. Lett. B 480 (2000) 273

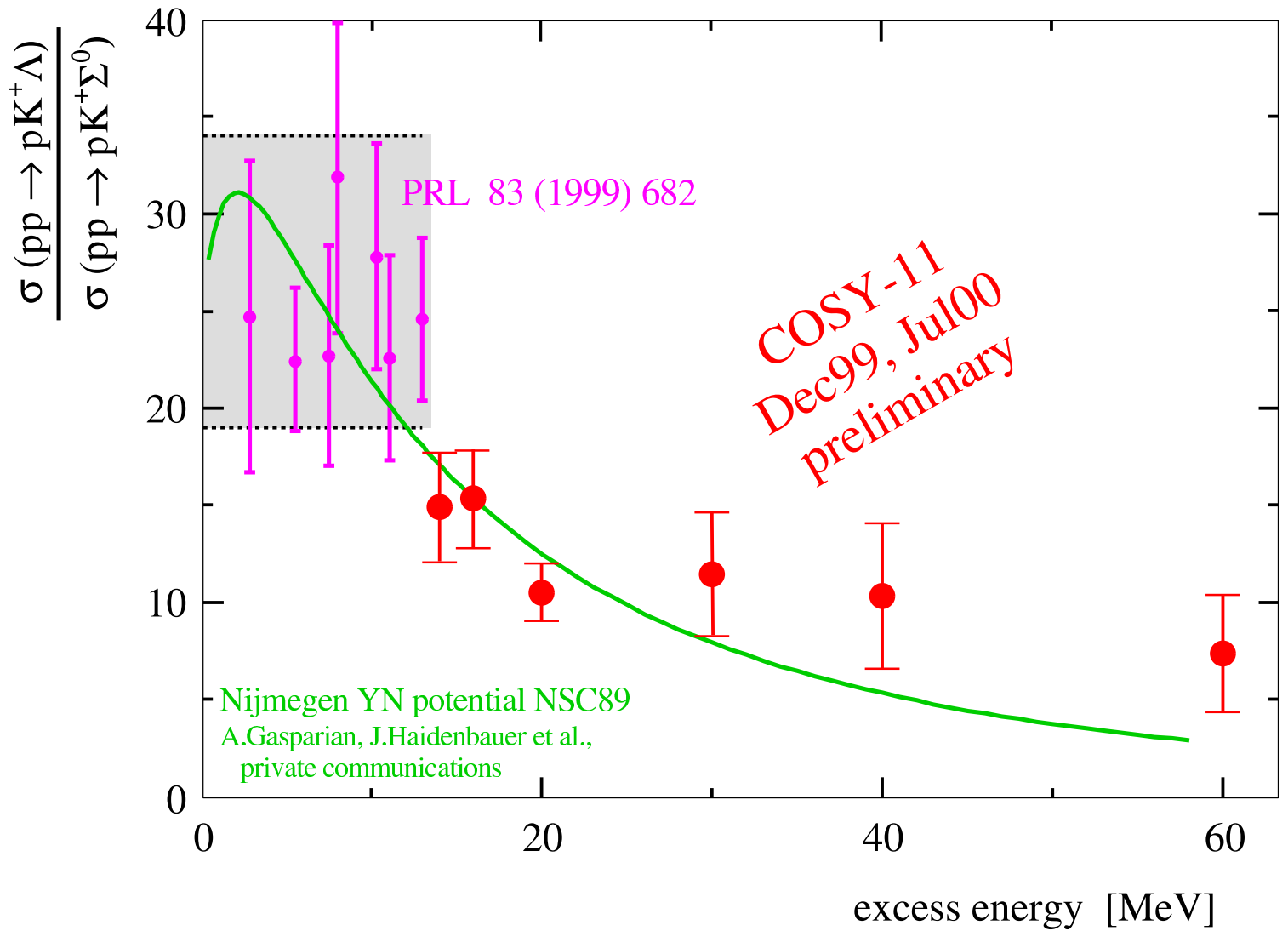


# Spin Transfer $\vec{p}p \rightarrow pK^+\vec{\Lambda}$

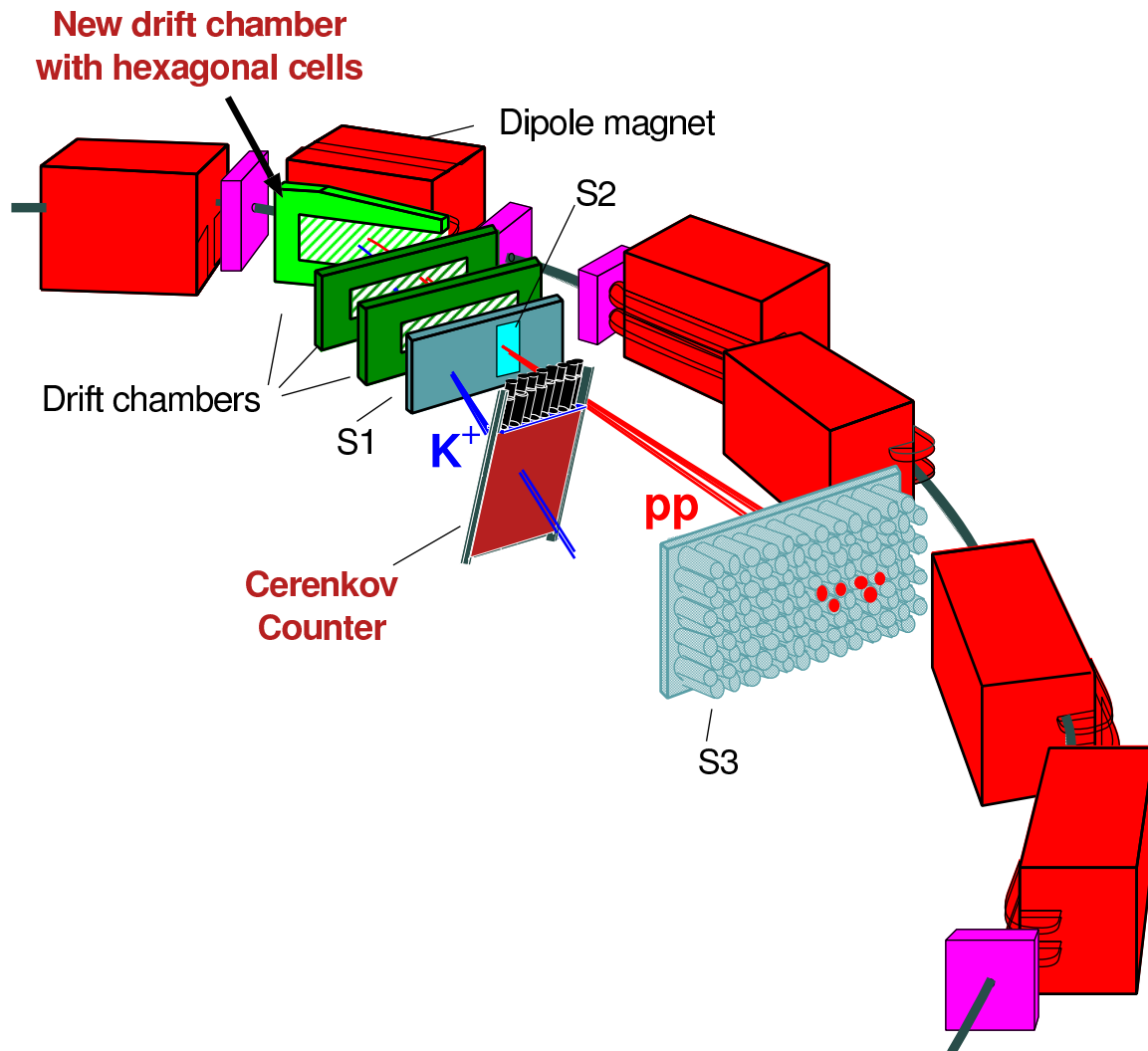
DISTO



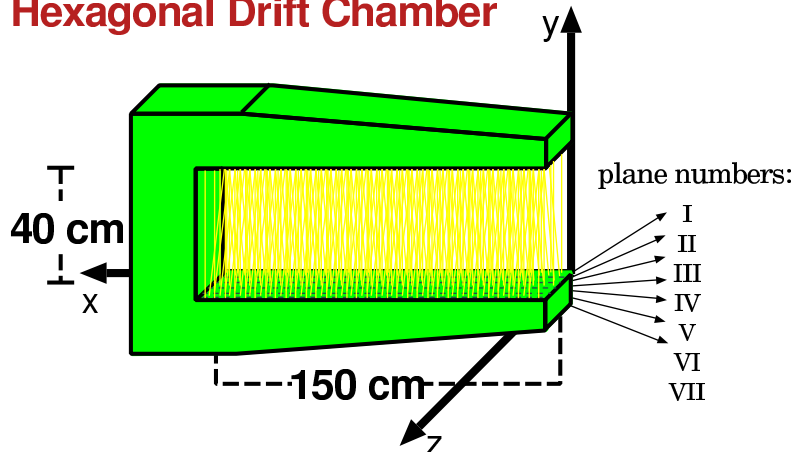
# $\Lambda/\Sigma^0$ Ratio - Energy Dependence



# COSY-11: The Kaon Identification System



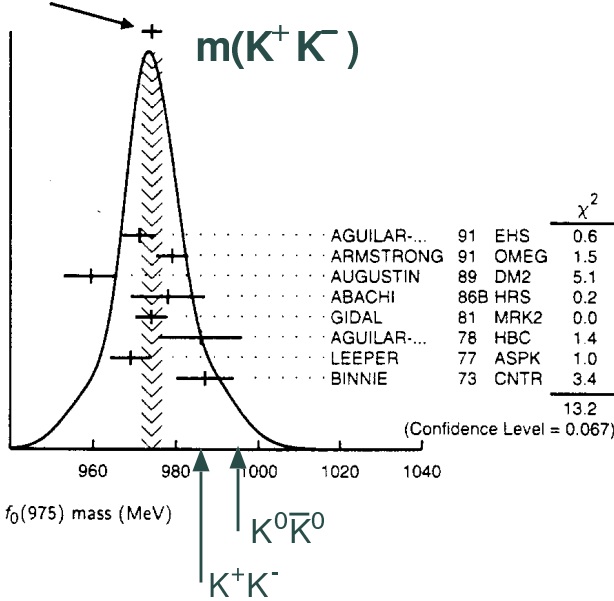
## Hexagonal Drift Chamber



Meson Full Listings

$f_0(975)$

WEIGHTED AVERAGE  
974.1±2.5 (Error scaled by 1.4)



$q\bar{q}q\bar{q}$

R.L.Jaffe

PR D15 (1977) 267

$q\bar{q}$

D.Morgan, M.R.Pennington

PR D48 (1993) 1185

$K\bar{K}$ -molecule

J.Weinstein, N.Isgur

PR D41 (1990) 2236

D.Lohse, J.W.Durso,

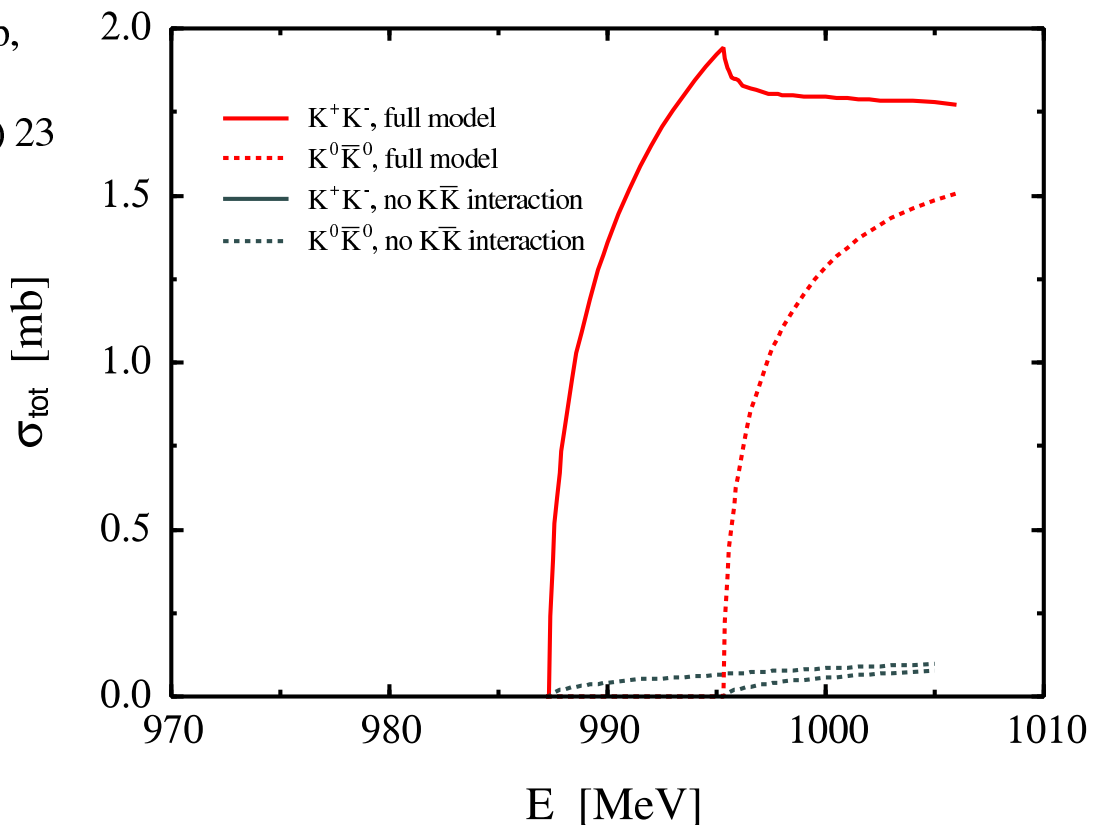
K.Holinde and J.Speth

NP A 516 (1990) 513

Jülich meson exchange model  
for  $\pi\pi$  and  $\pi\eta$  scattering

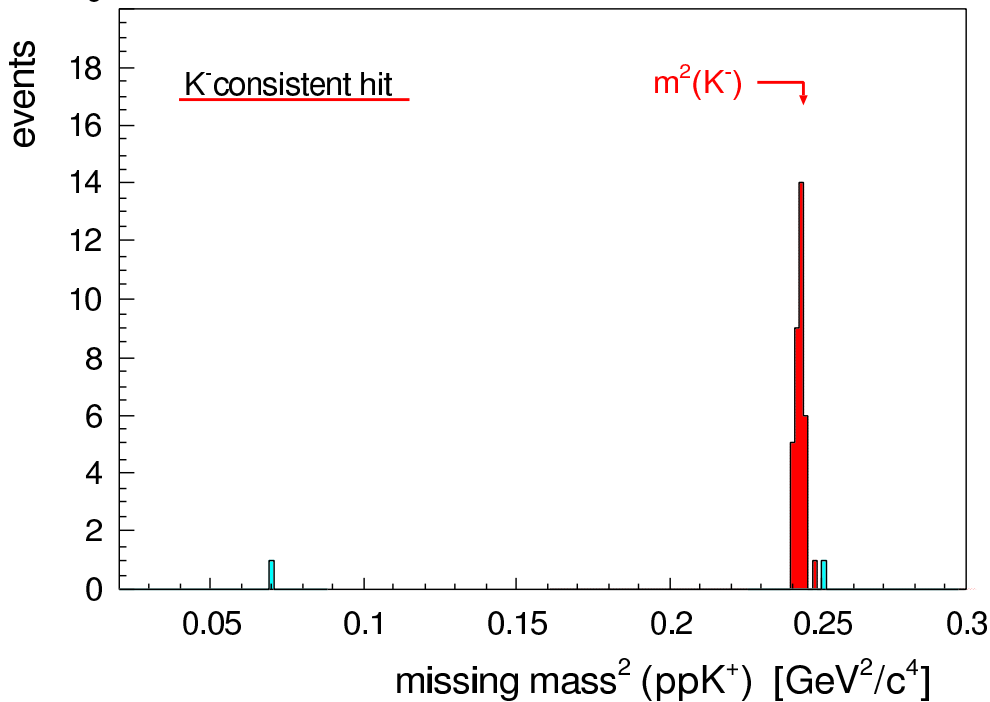
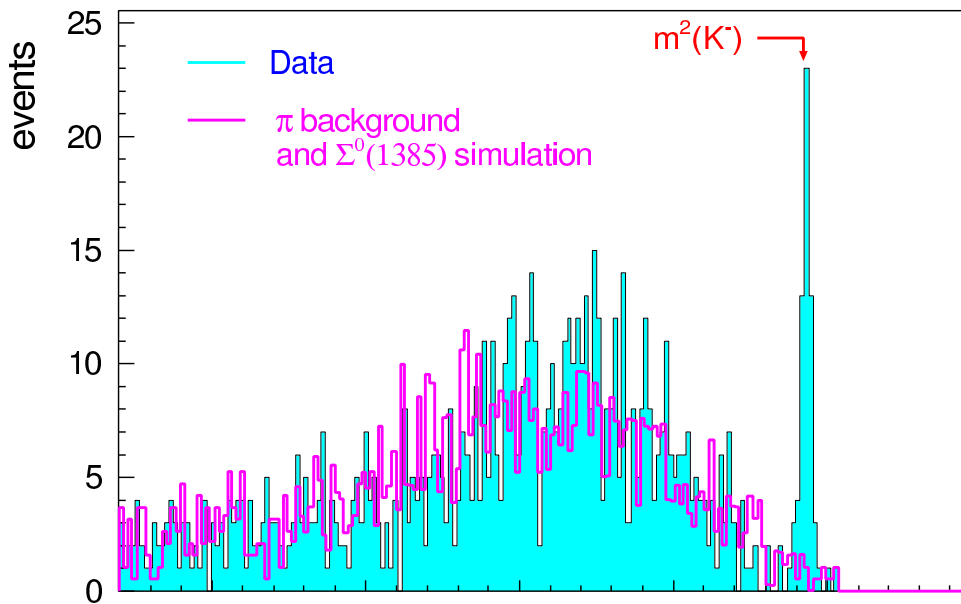
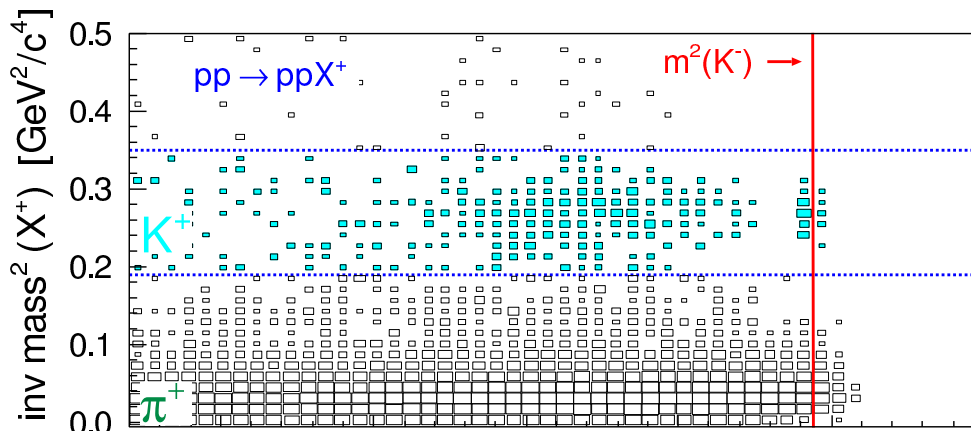
$\pi^+\pi^- \rightarrow K\bar{K}$

O.Krehl, R.Rapp,  
J.Speth  
PL B390 (1997) 23



$pp \rightarrow ppK^+K^-$

$Q = 17\text{MeV}$

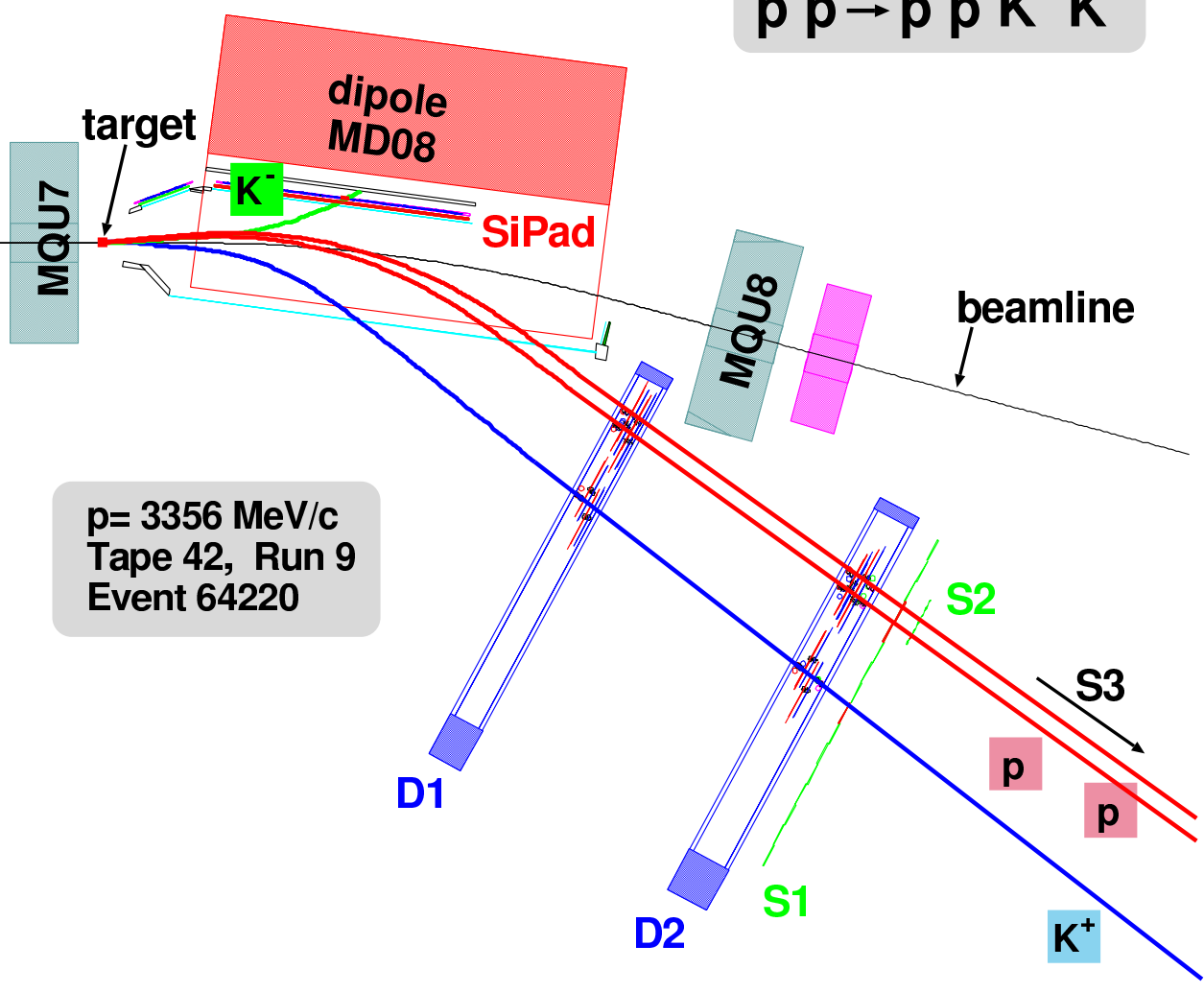


$$\sigma(pp \rightarrow ppK^+K^-) = 1.80 \pm 0.27^{+0.28}_{-0.35} \text{ nb}$$

C.Quentmeier,  
Westf. Wilhelms-Univ. Münster,  
PhD Thesis (2001)  
Phys. Lett. B 515 (2001) 276

# COSY-11: Experimental Setup

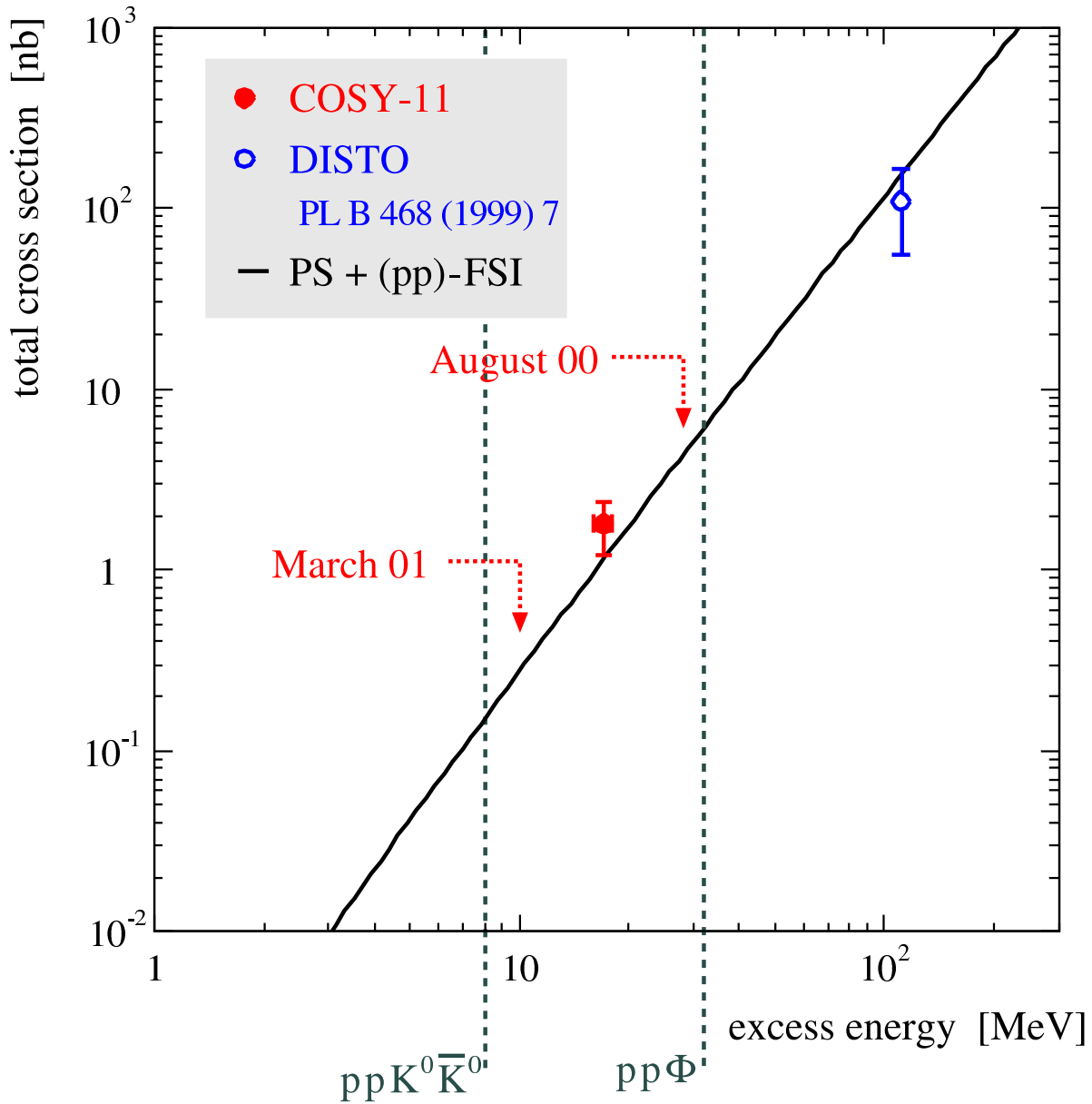
$p p \rightarrow p p K^+ K^-$



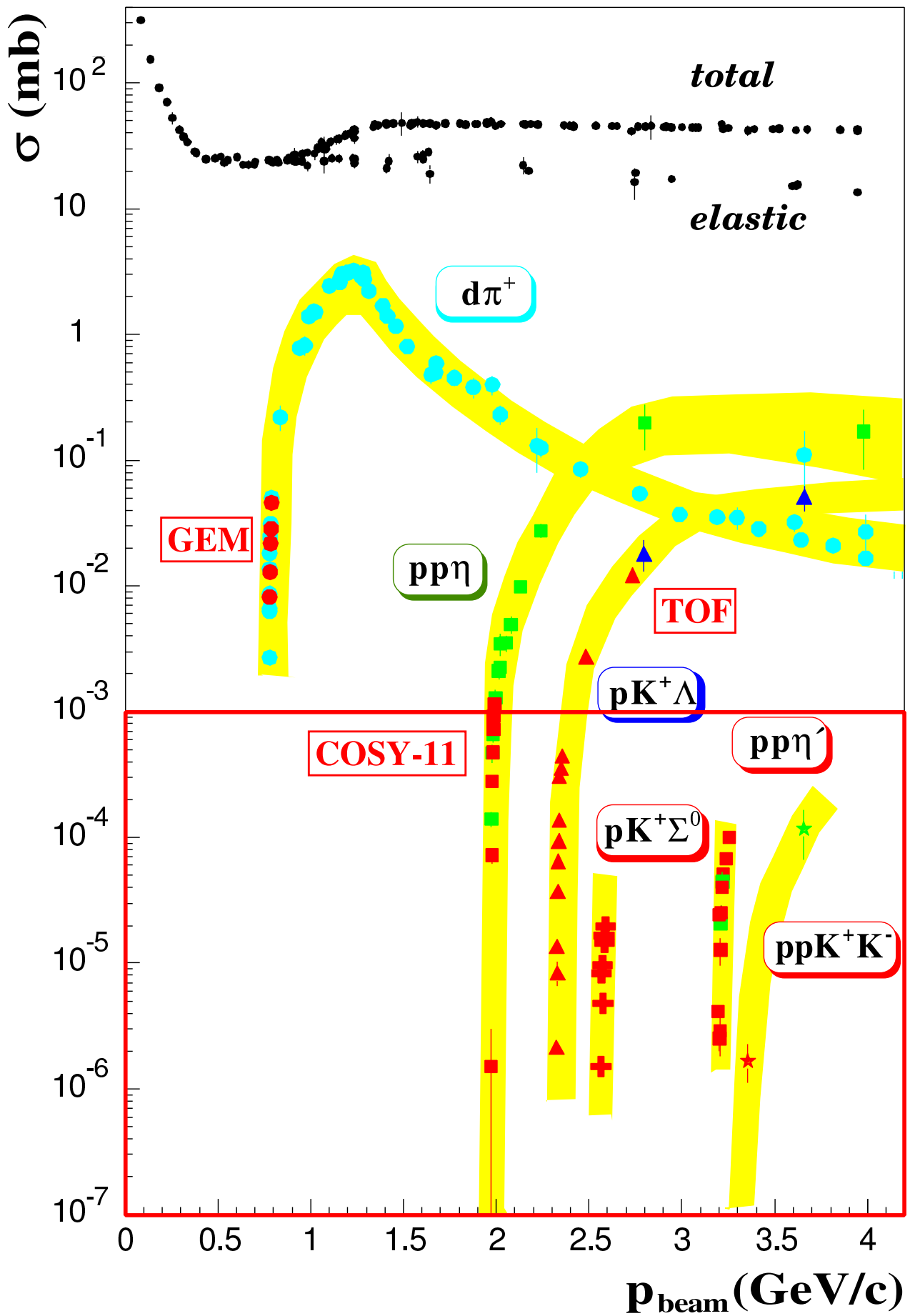
$p = 3356 \text{ MeV}/c$   
Tape 42, Run 9  
Event 64220



# $pp \rightarrow ppK^+K^-$ close to threshold



# Cross Sections for $pp \rightarrow$





# COSY-11 Collaboration

September 2001

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