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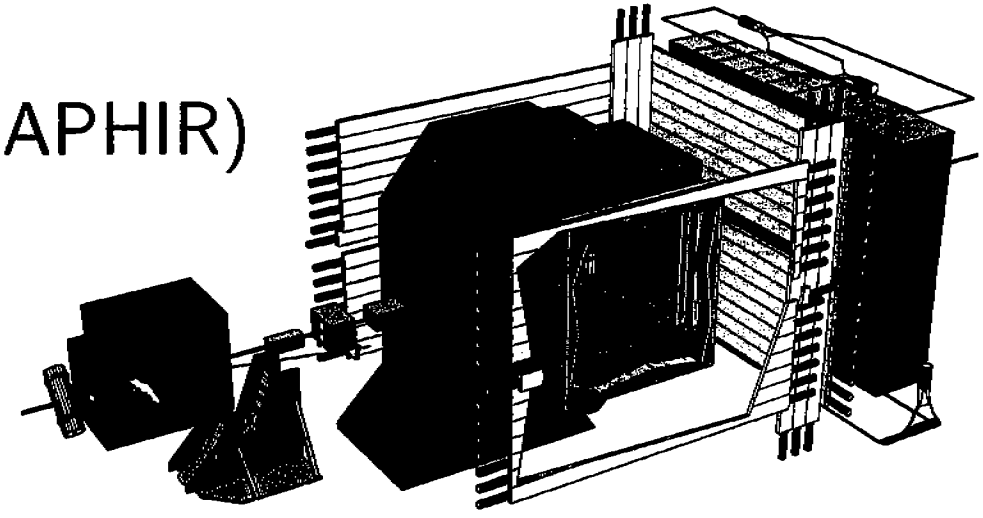
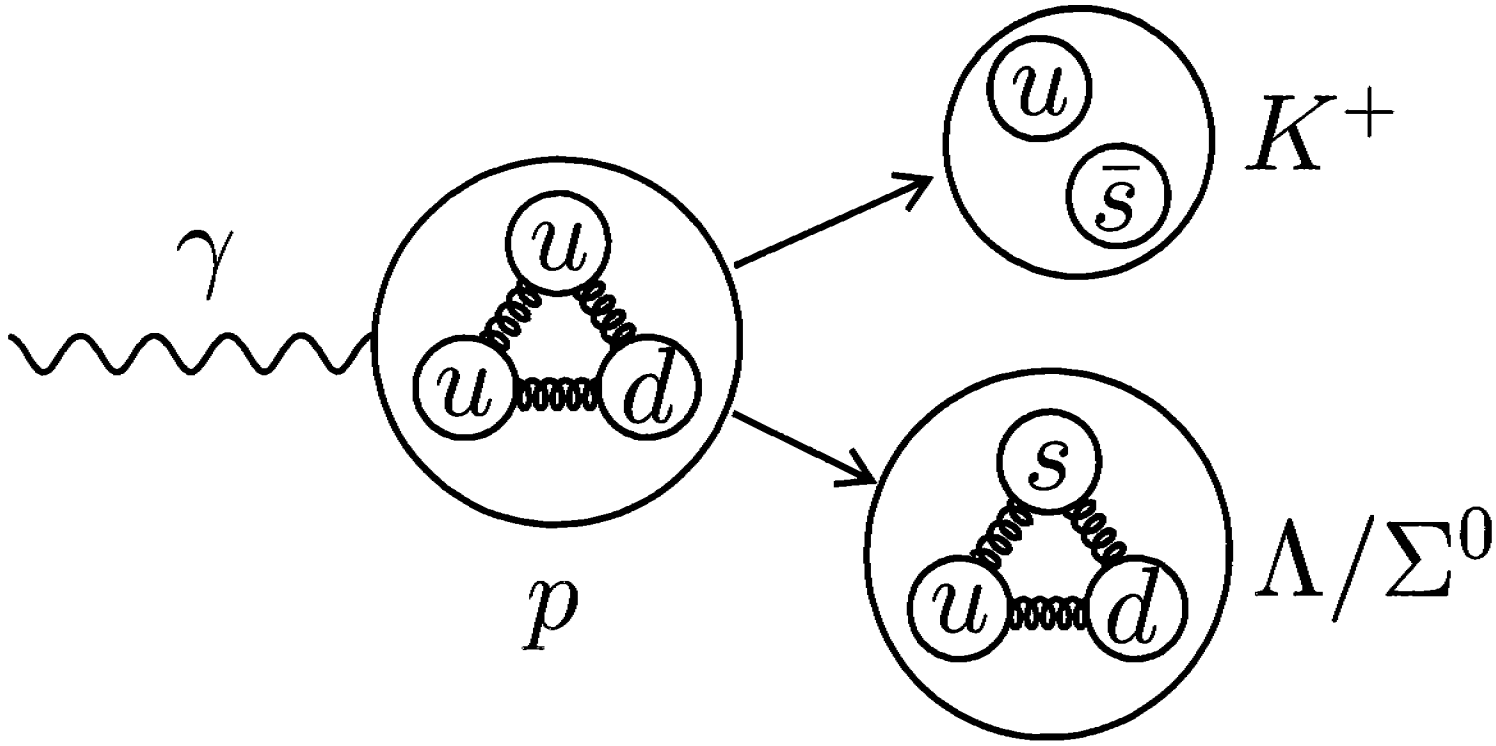
Kaon Photoproduction at SAPHIR for photon energies up to 2.6 GeV

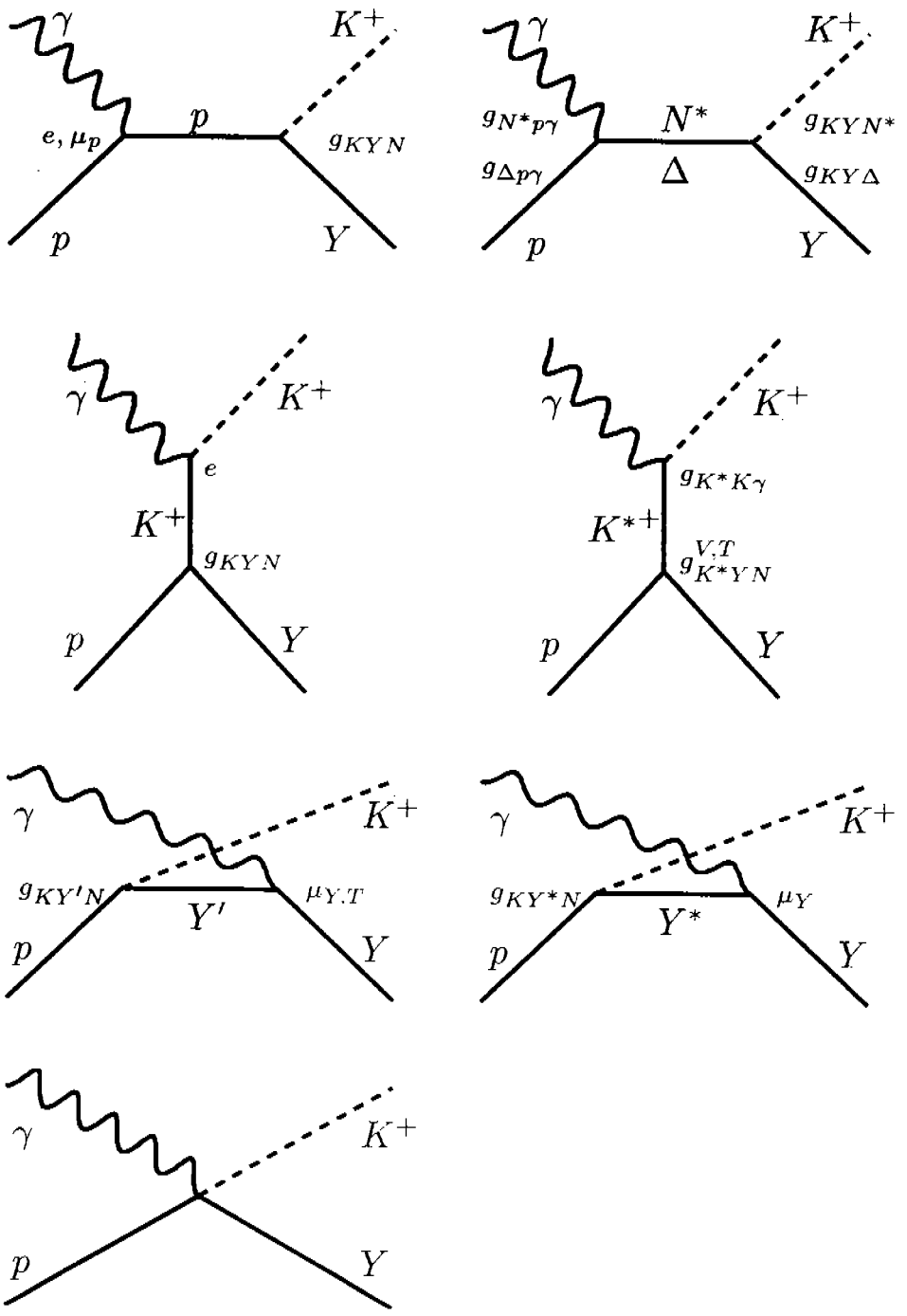
- Motivation
- The experiment (ELSA/SAPHIR)
- Results
- Discussion




γ
u
u
d
p
u
$\bar{s}$
K^+
s
u
d
Λ/Σ^0

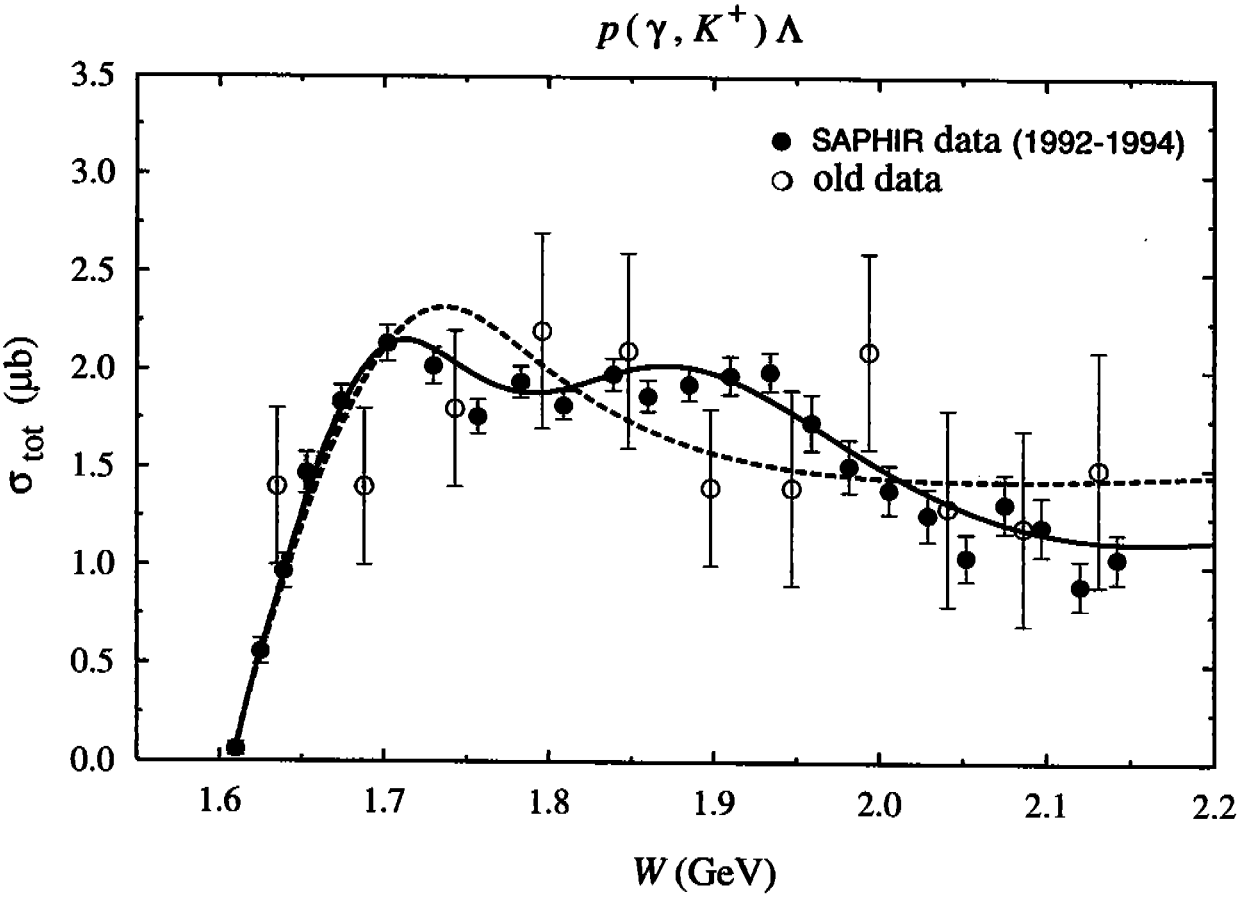
Isobare models

Quark degrees of freedom are frozen in hadronic degrees of freedom



SAPHIR I: 1992-1994

total cross section $\gamma p \to K^+\Lambda$

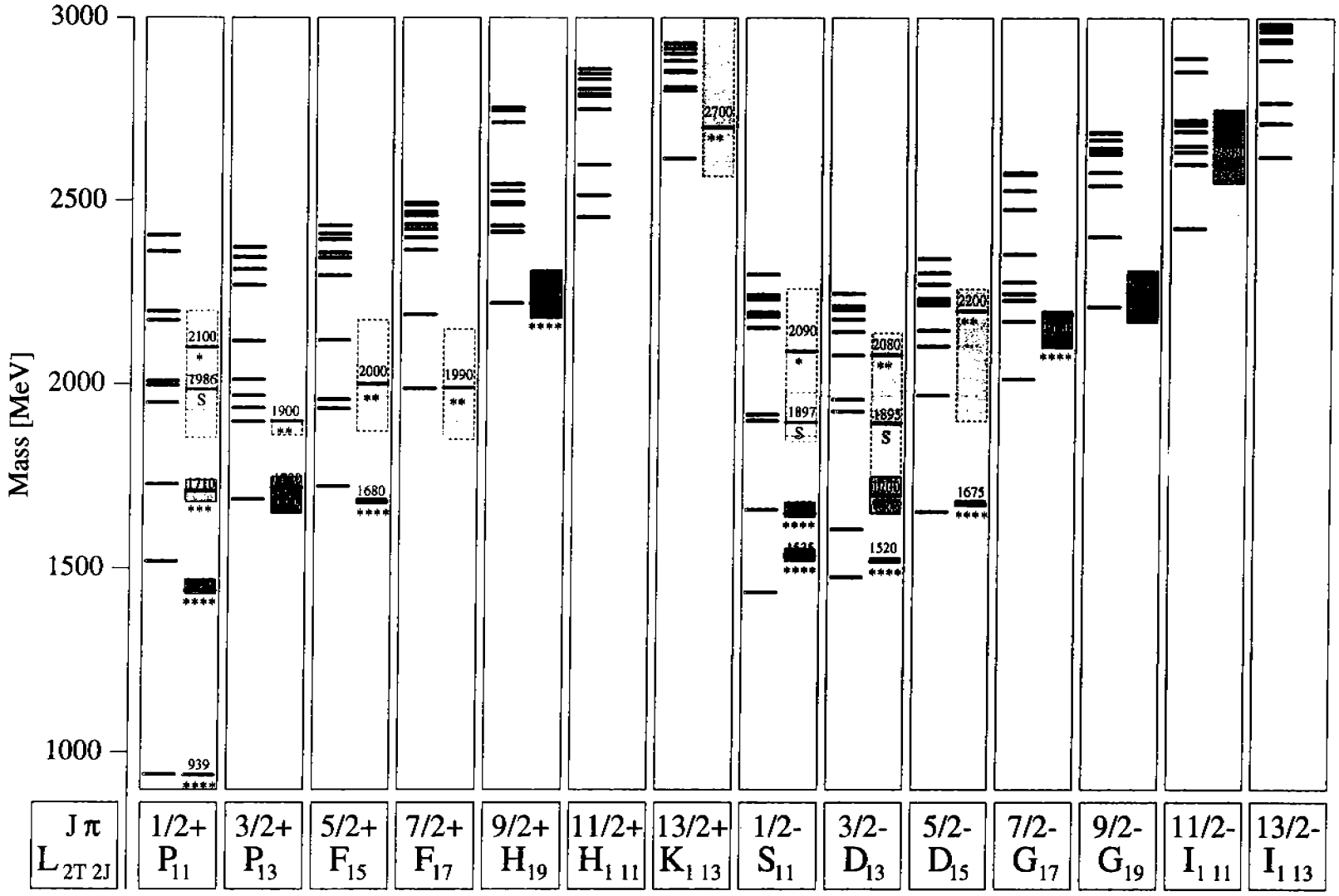


isobare model (C. Bennhold et al.; 2000) with t–channel–poles ($K^*(892)$ and $K_1(1270)$)

and s–channel-resonances $S_{11}(1650)$, $P_{11}(1710)$,$P_{13}(1720)$

$+ D_{13}(1895)$ **???**

nucleon spectrum



U. Löring, K. Kretzschmar, B. Ch. Metsch a. H. R. Petry

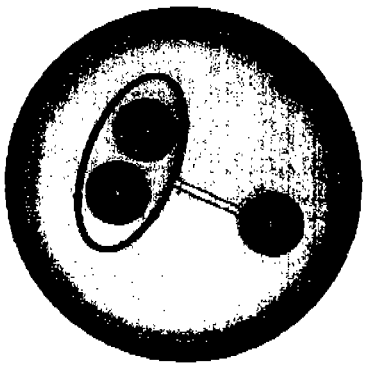
Eur. Phys. J. A 10, 395 (2001): "The light baryon spectrum in a relativistic quark model with instanton-induced quark forces: I. The non-strange baryon spectrum and ground states"

Missing resonances

Quark Models: more baryons predicted than observed

Possible solutions:

a) **Baryons have a quark-diquark structure:**



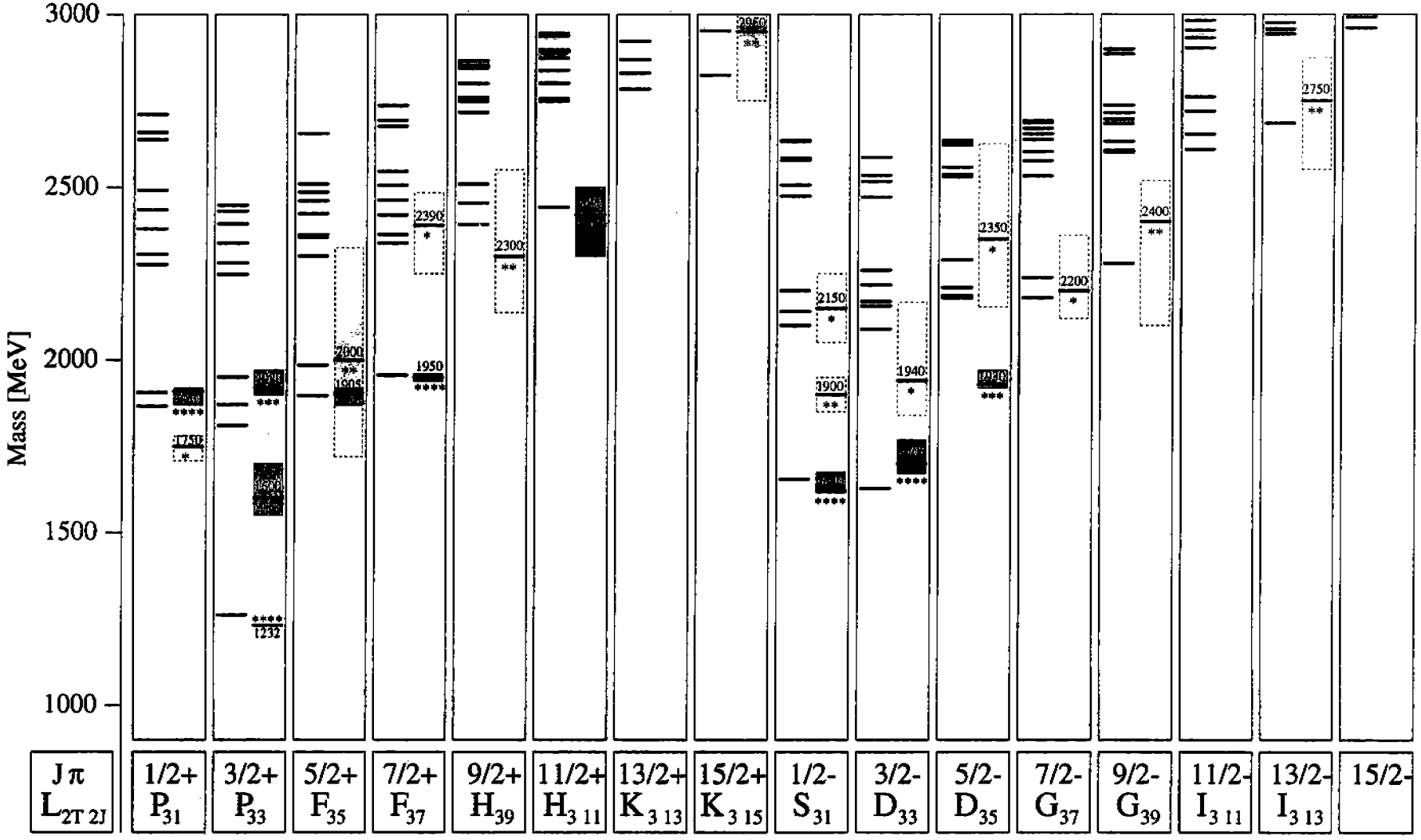
one of the internal degrees of freedom is frozen

b) **They have not been observed up to now:**

Nearly all existing data result from πN-scattering experiments

$\Rightarrow$ If the missing resonances do not couple to πN, they would not have been discovered!!! (supported by theory)

Δ spectrum



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The SAPHIR experiment

The ELSA accelerator

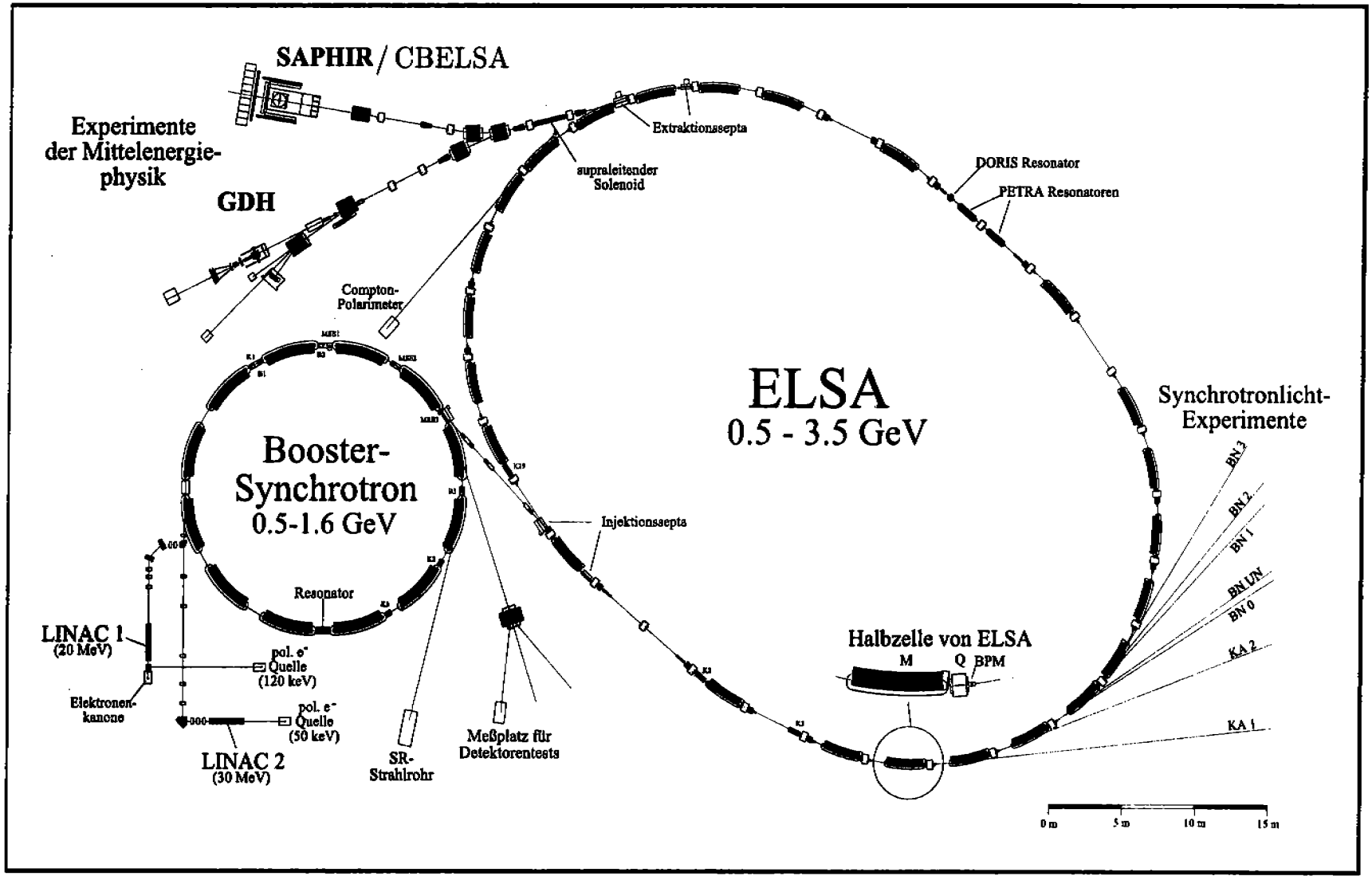
ELSA = Electron Stretcher and Accelerator

Energy of electrons:

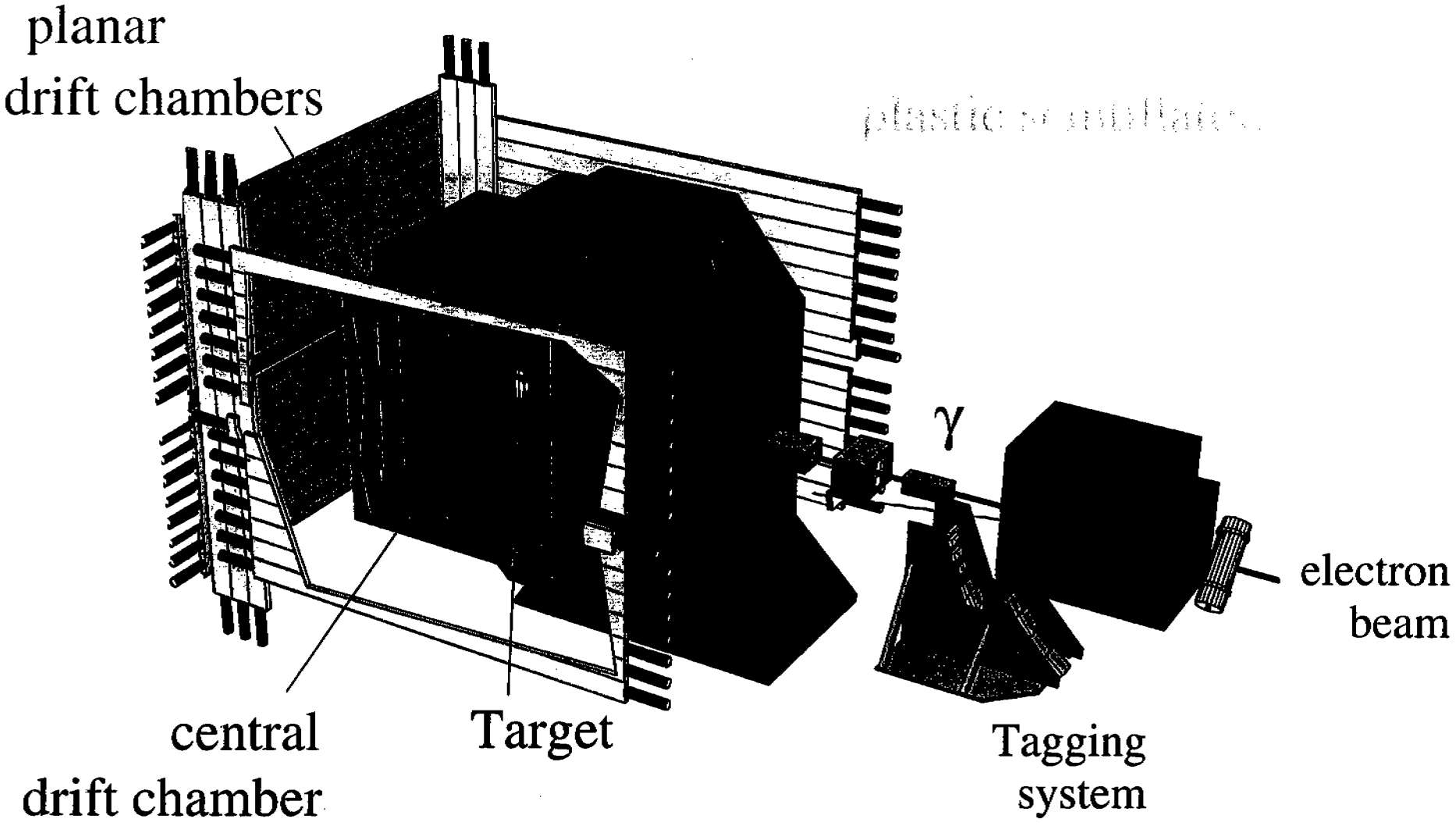
0.5 GeV

-

2.8 GeV

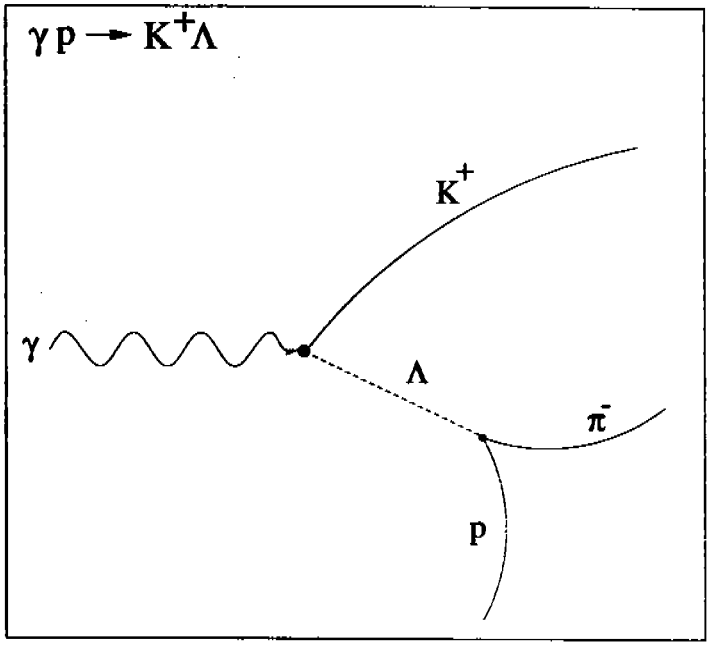


The SAPHIR detector



topology of reactions $\gamma p \to K^+\Lambda$ resp. $K^+\Sigma^0$

$\gamma p \to K^+\Lambda$

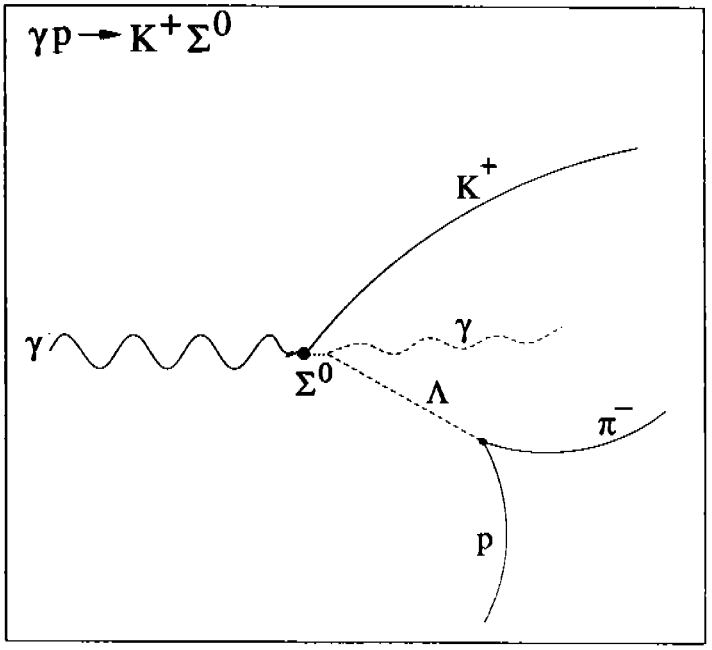


$\Lambda \to p\pi^-$ (63.9%)

$\Lambda \to n\pi^0$ (35.8%)

threshold:
$E_\gamma = 0.910$ GeV
$\sqrt{s} = 1.609$ GeV

$\gamma p \to K^+\Sigma^0$



$\Sigma^0 \to \Lambda\gamma$ (100%)

threshold:
$E_\gamma = 1.046$ GeV
$\sqrt{s} = 1.686$ GeV

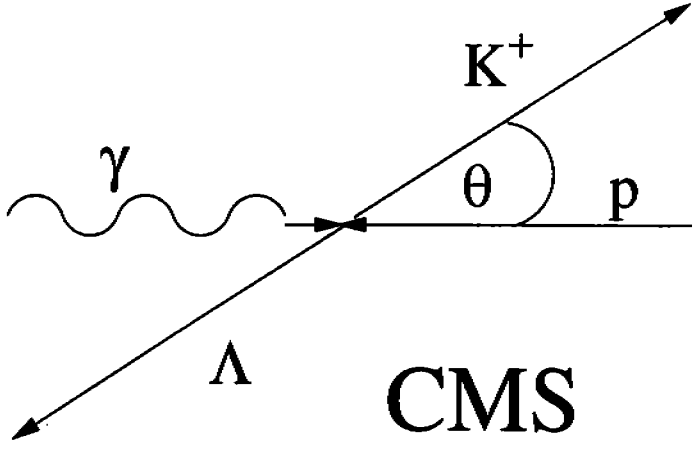
- topology fit for Λ-Vertex + primary vertex
- kinematical fit for desired reaction

differential and total cross sections of the reactions

$\gamma p \to K^+\Lambda$ and $\gamma p \to K^+\Sigma^0$

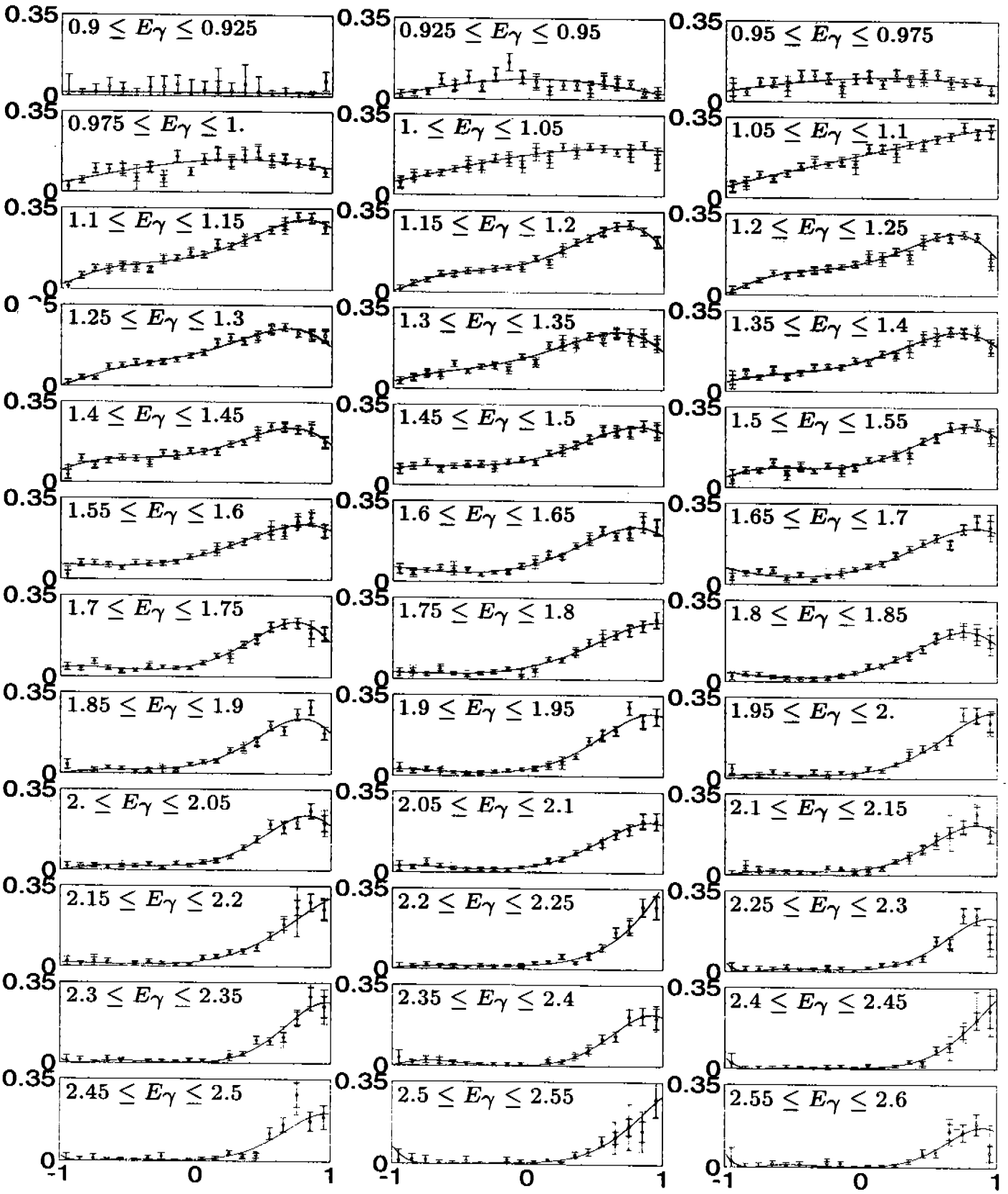
$E_\gamma(K^+\Lambda\ ) : 0.9\ \ -2.6\,GeV$

$E_\gamma(K^+\Sigma^0) : 1.05 - 2.6\,GeV$



Differential cross section

$\frac{d\sigma}{d\Omega}$ $[\frac{\mu b}{sr}]$ $\gamma p \to K^+\Lambda$

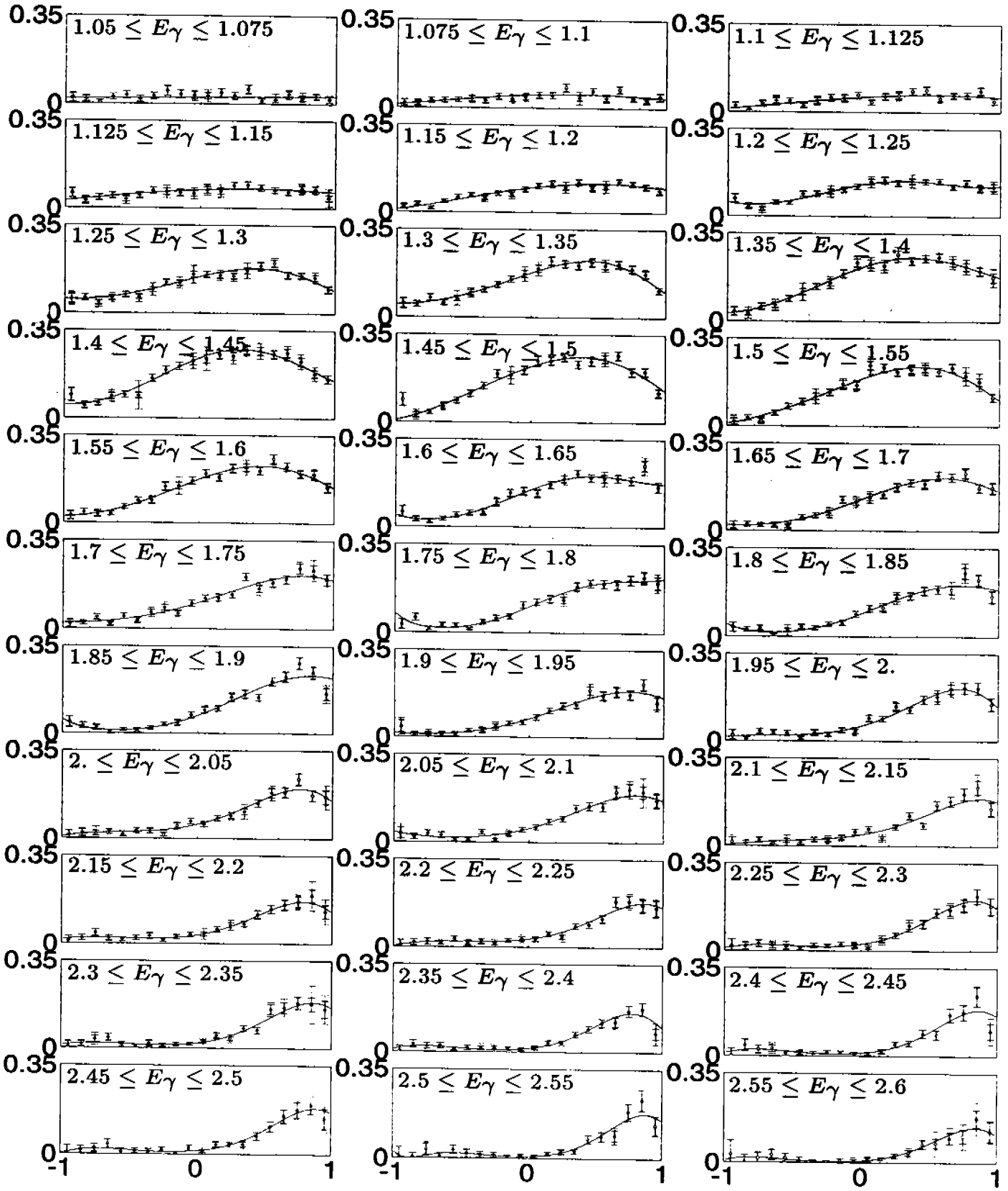


SAPHIR: 1997/1998

$\cos\theta_K^{CMS}$

Differential cross section

$\frac{\mathbf{d}\sigma}{\mathbf{d}\,\Omega}\ [\frac{\mu b}{sr}]$ $\gamma p \to K^+\Sigma^0$



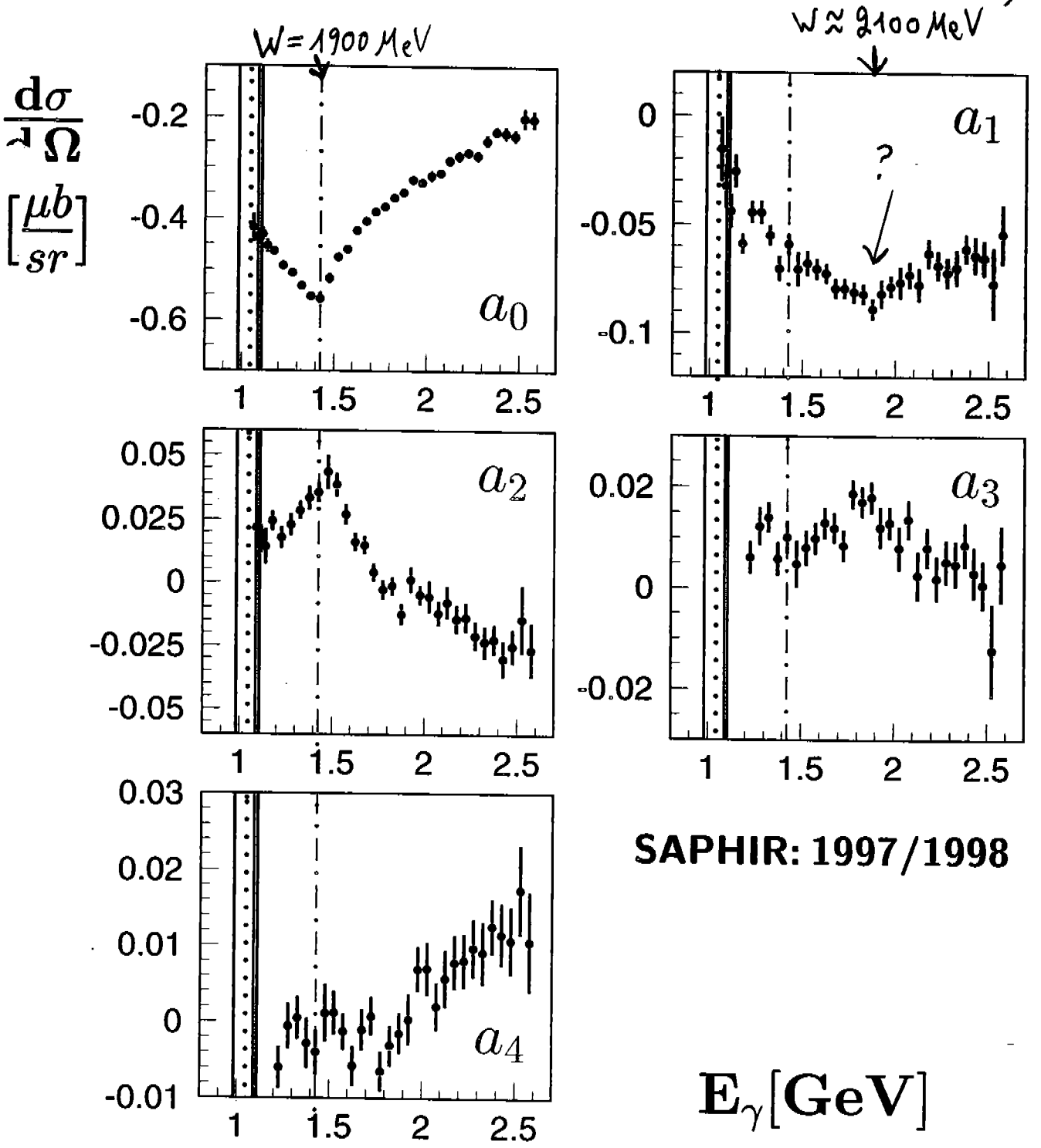
SAPHIR: 1997/1998

$\cos\theta_{\mathrm{K}}^{\mathrm{CMS}}$

Differential cross sections

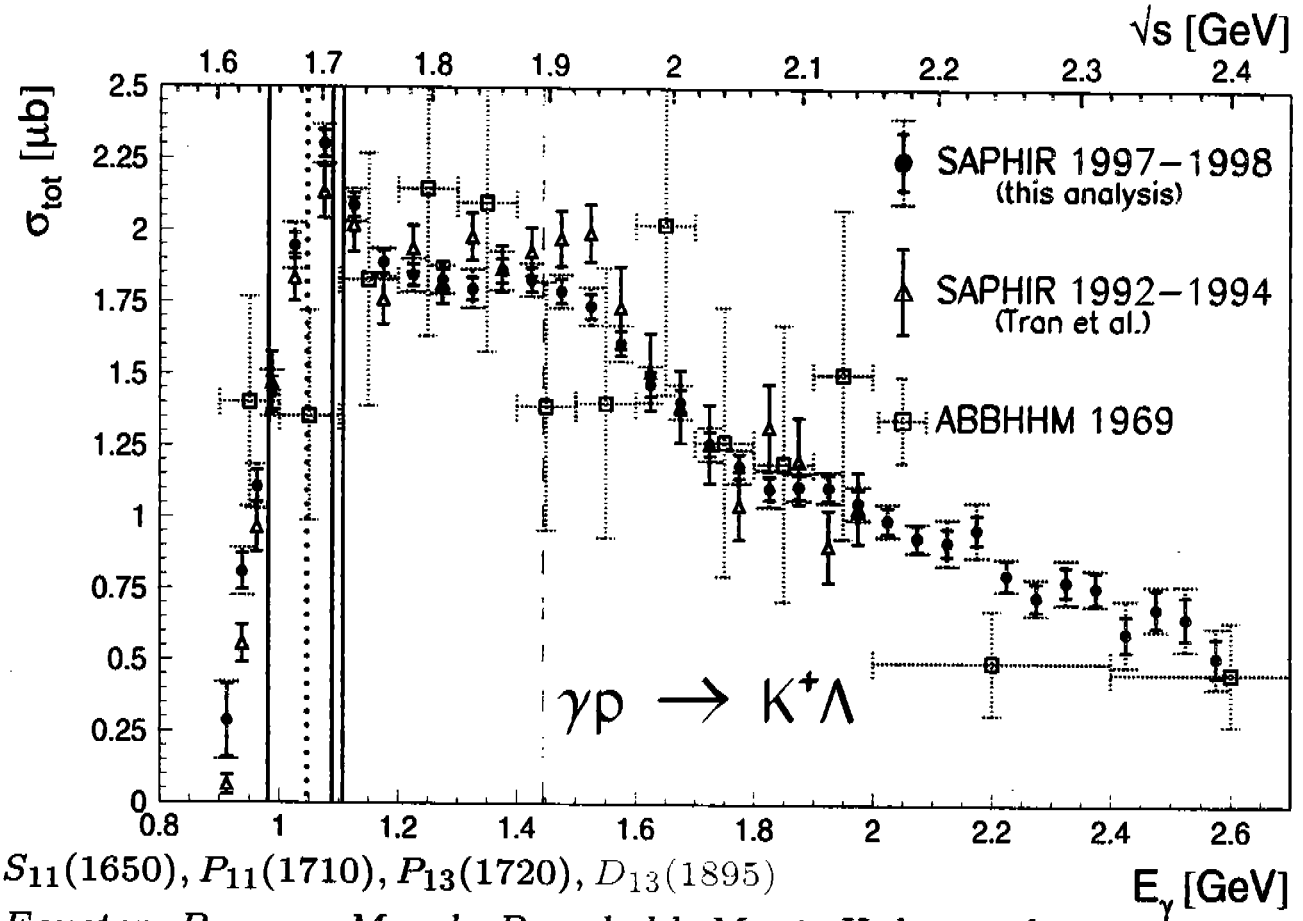
$\gamma p \to K^+\Sigma^0$: Legendre polynomials

$$\frac{d\sigma}{d\Omega} = \frac{q}{k}\left(\sum_{l=0}^{4}(2l+1)\,a_l\,P_l(cos\,\Theta_K^{CMS})\right)^2$$



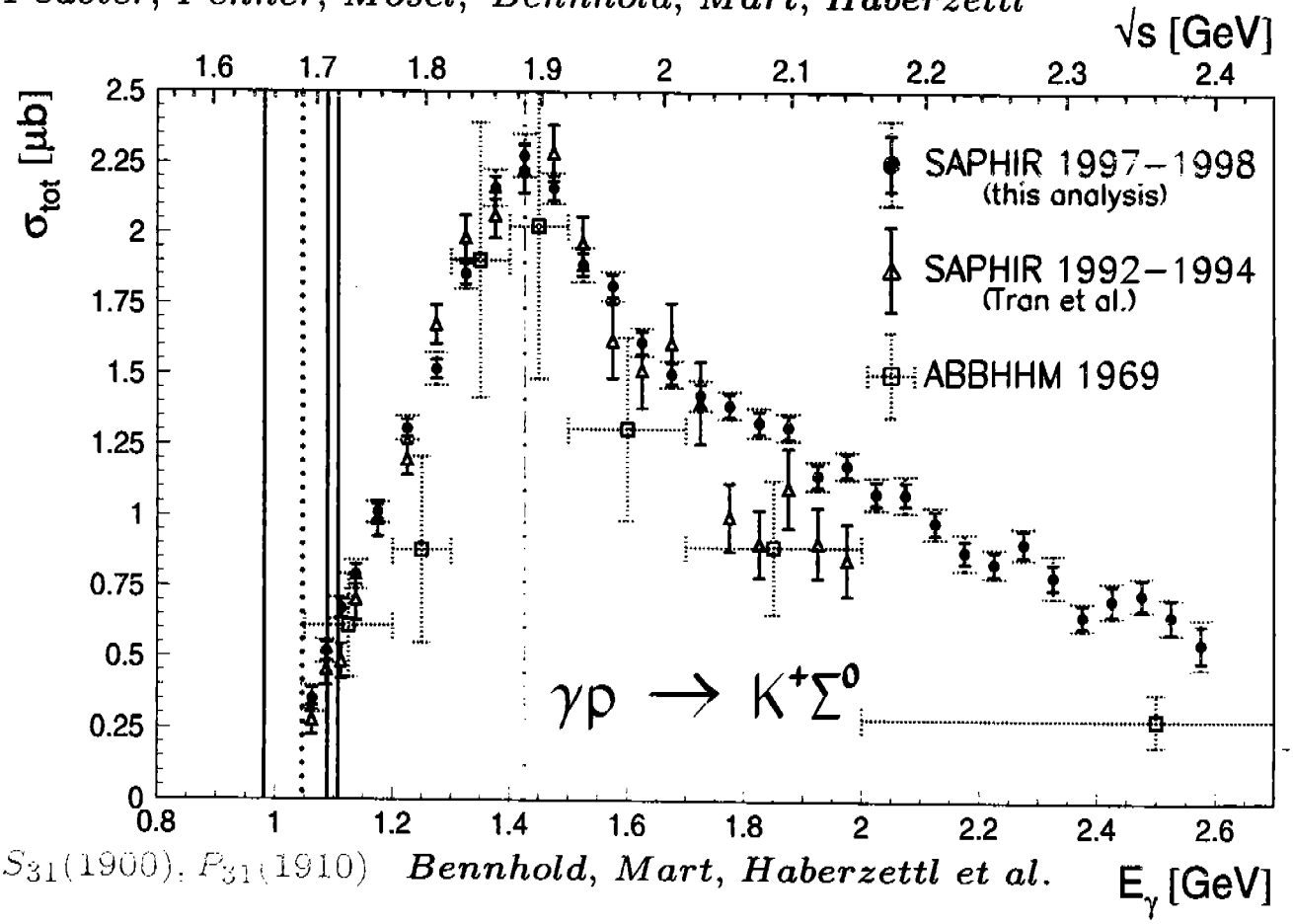
SAPHIR: 1997/1998

Total cross section



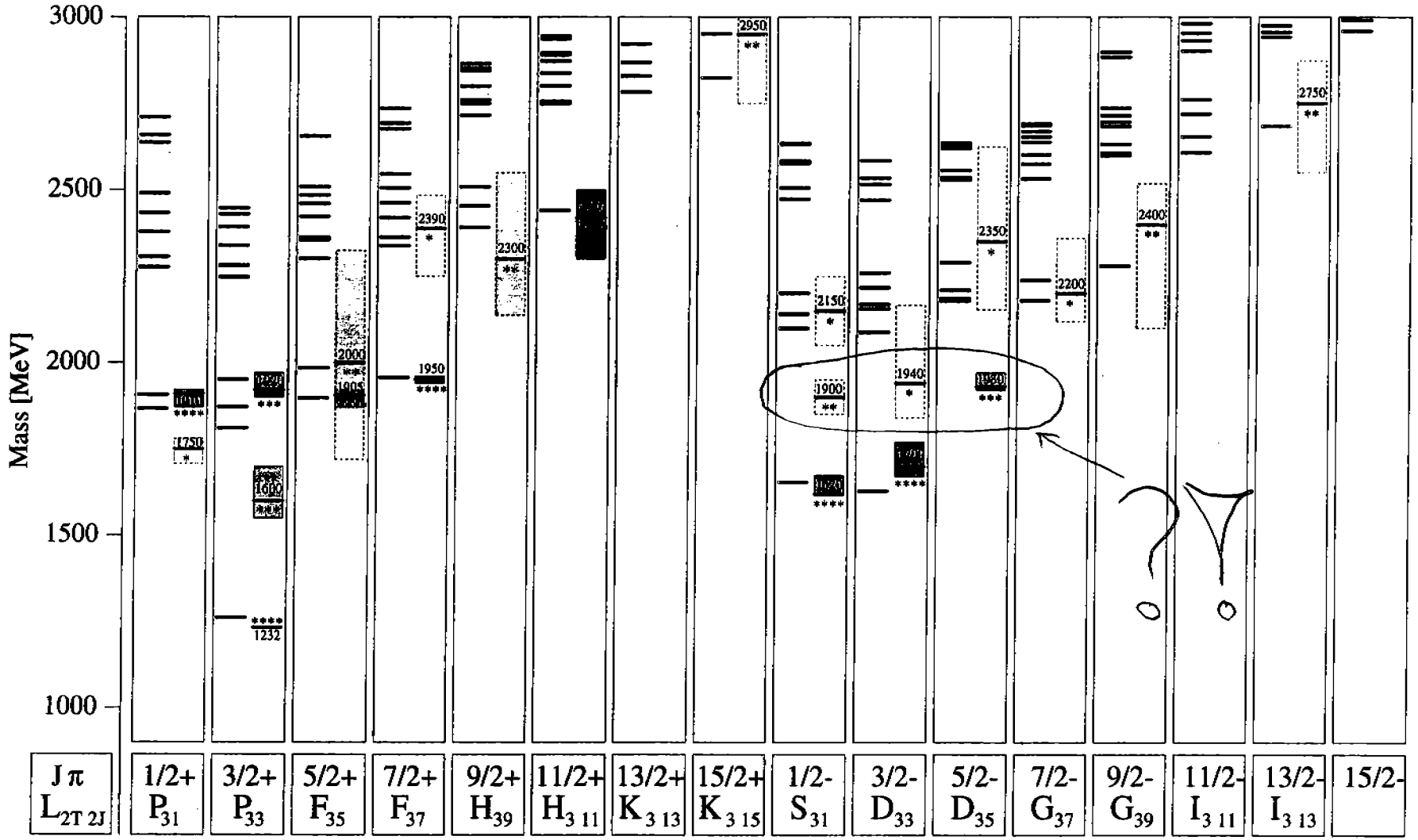
$S_{11}(1650), P_{11}(1710), P_{13}(1720), D_{13}(1895)$

Feuster, Penner, Mosel; Bennhold, Mart, Haberzettl



$S_{31}(1900), P_{31}(1910)$ *Bennhold, Mart, Haberzettl et al.*

Δ spectrum



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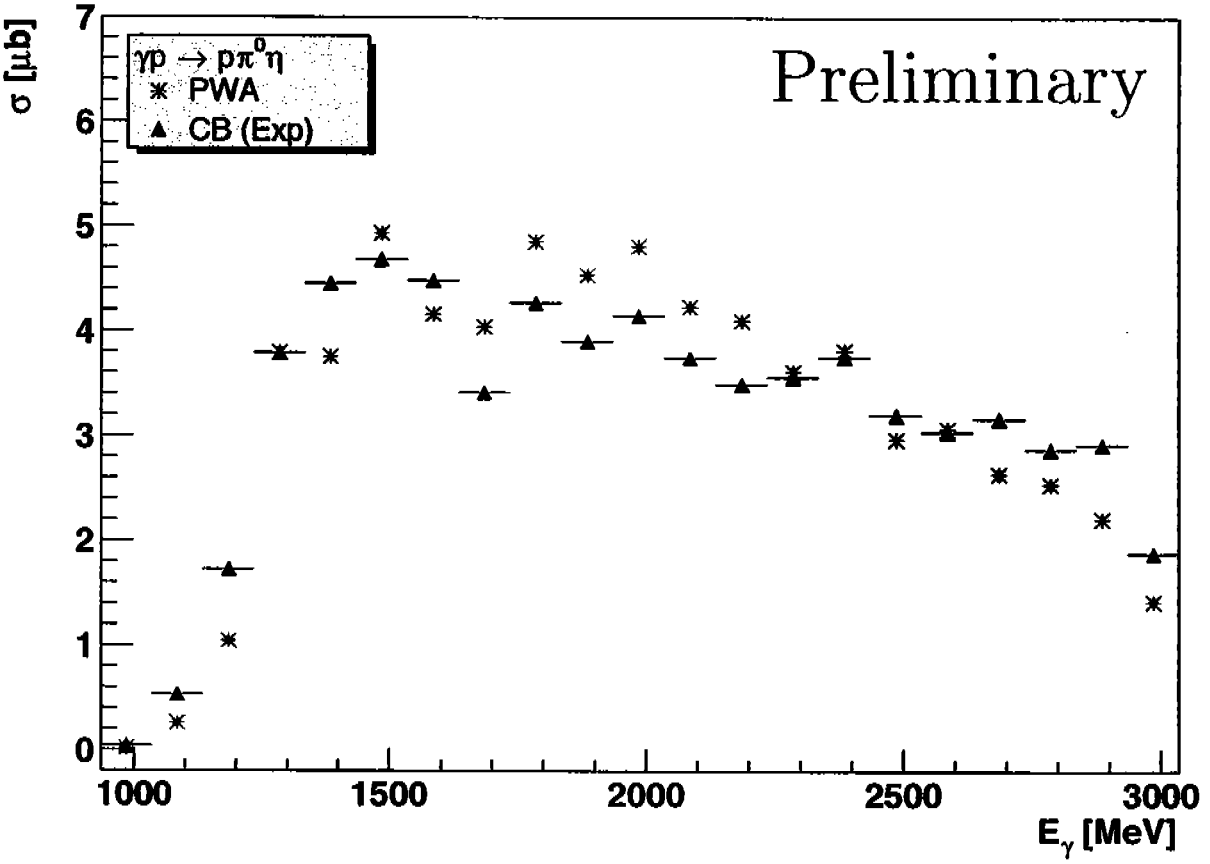
Total cross section for $\gamma\,p \rightarrow p\,\pi^0\,\eta$ First results of a PWA

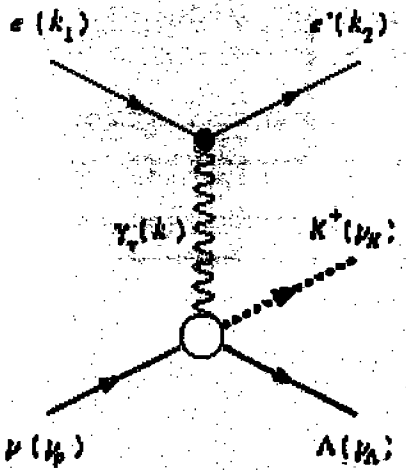
Total cross section



Preliminary solution

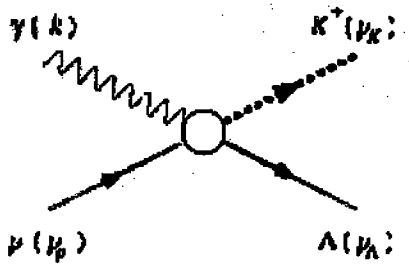
I	J^P	mass	width		PDG
$\frac{3}{2}$	$\frac{1}{2}^-$	≈ 2400	≈ 300	≈ 20 %	
$\frac{3}{2}$	$\frac{3}{2}^-$	≈ 2175	300 - 400	≈ 35 %	
$\frac{3}{2}$	$\frac{3}{2}^-$	≈ 1915	≈ 200	≈ 8 %	$\Delta(1940)D_{33}$ (*)
$\frac{3}{2}$	$\frac{5}{2}^-$	≈ 1965	300 - 400	≈ 7 %	$\Delta(1930)D_{35}$ (***)
$\frac{3}{2}$	$\frac{1}{2}^+$	≈ 1940	≈ 300	≈ 16 %	$\Delta(1910)P_{31}$ (****)
$\frac{3}{2}$	$\frac{3}{2}^+$	≈ 2390	300 - 400	≈ 6 %	
$\frac{3}{2}$	$\frac{5}{2}^+$	≈ 1945	300 - 400	≈ 11 %	$\Delta(1905)F_{35}$ (****)

Elementary Process



$k^2 \neq 0$

$k = k_1 - k_2$

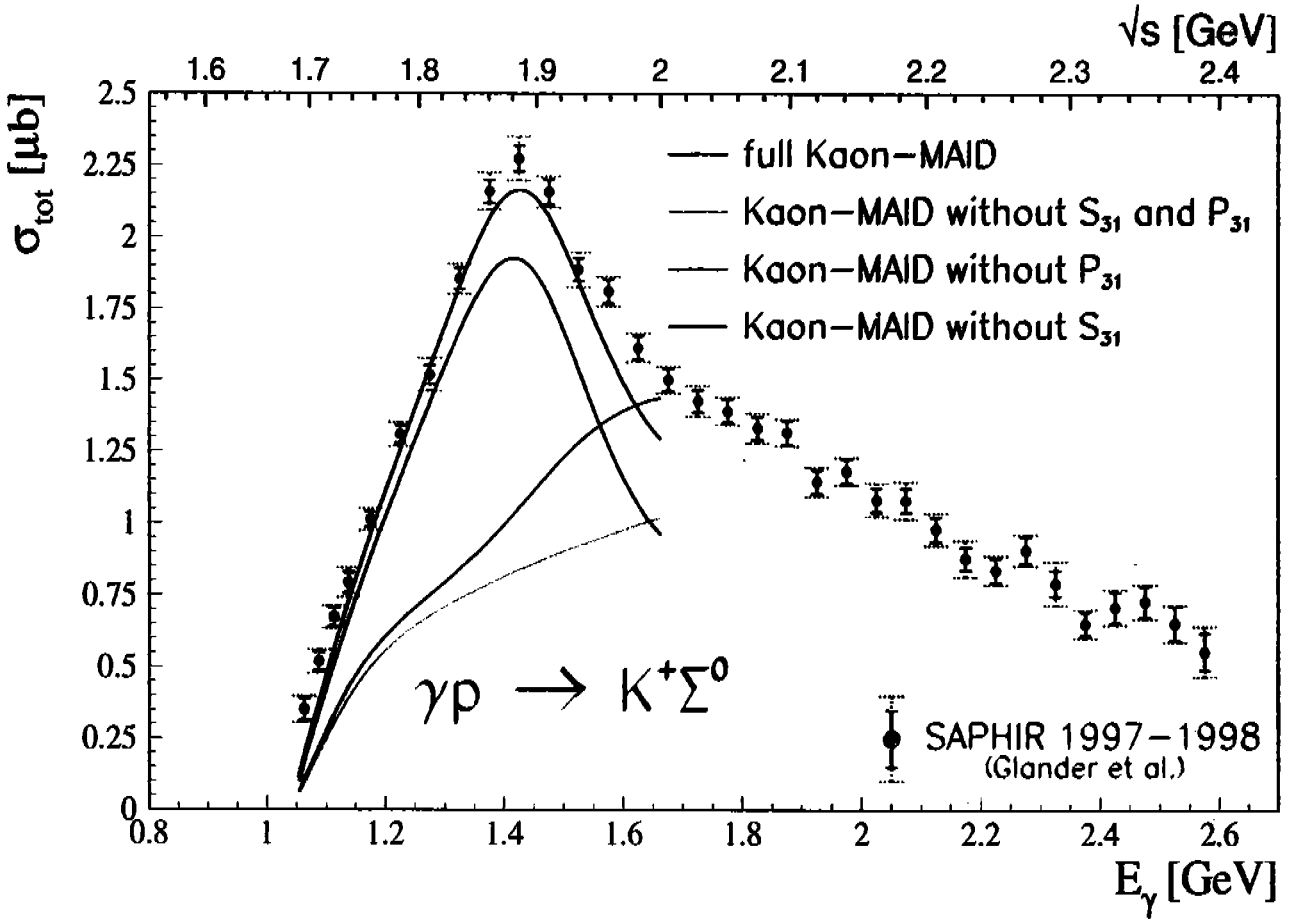


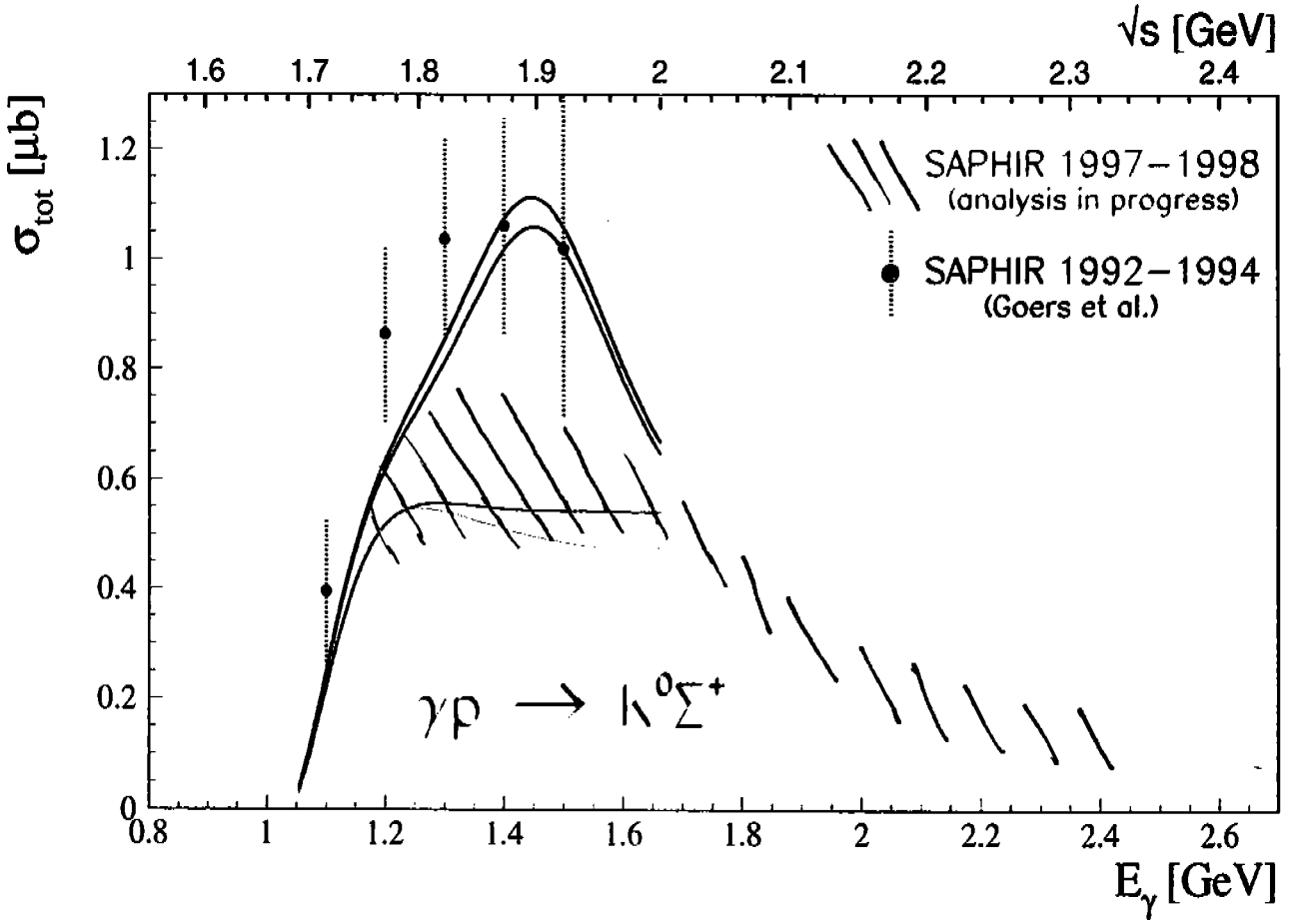
$k^2 = 0$

six possible isospin channels :

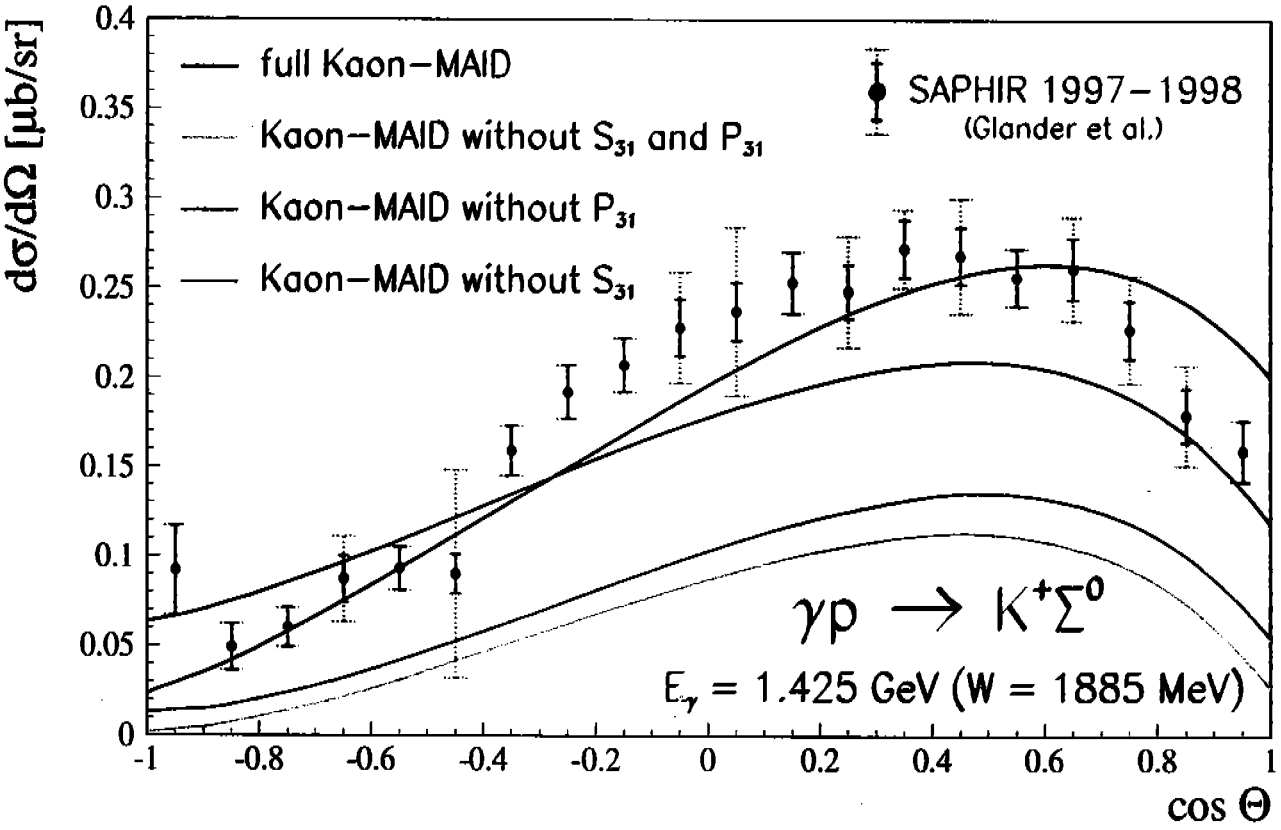
1. $p(\gamma, K^+)\Lambda$
2. $p(\gamma, K^+)\Sigma^0$
3. $p(\gamma, K^0)\Sigma^+$
4. $n(\gamma, K^+)\Sigma^-$
5. $n(\gamma, K^0)\Lambda$
6. $n(\gamma, K^0)\Sigma^0$

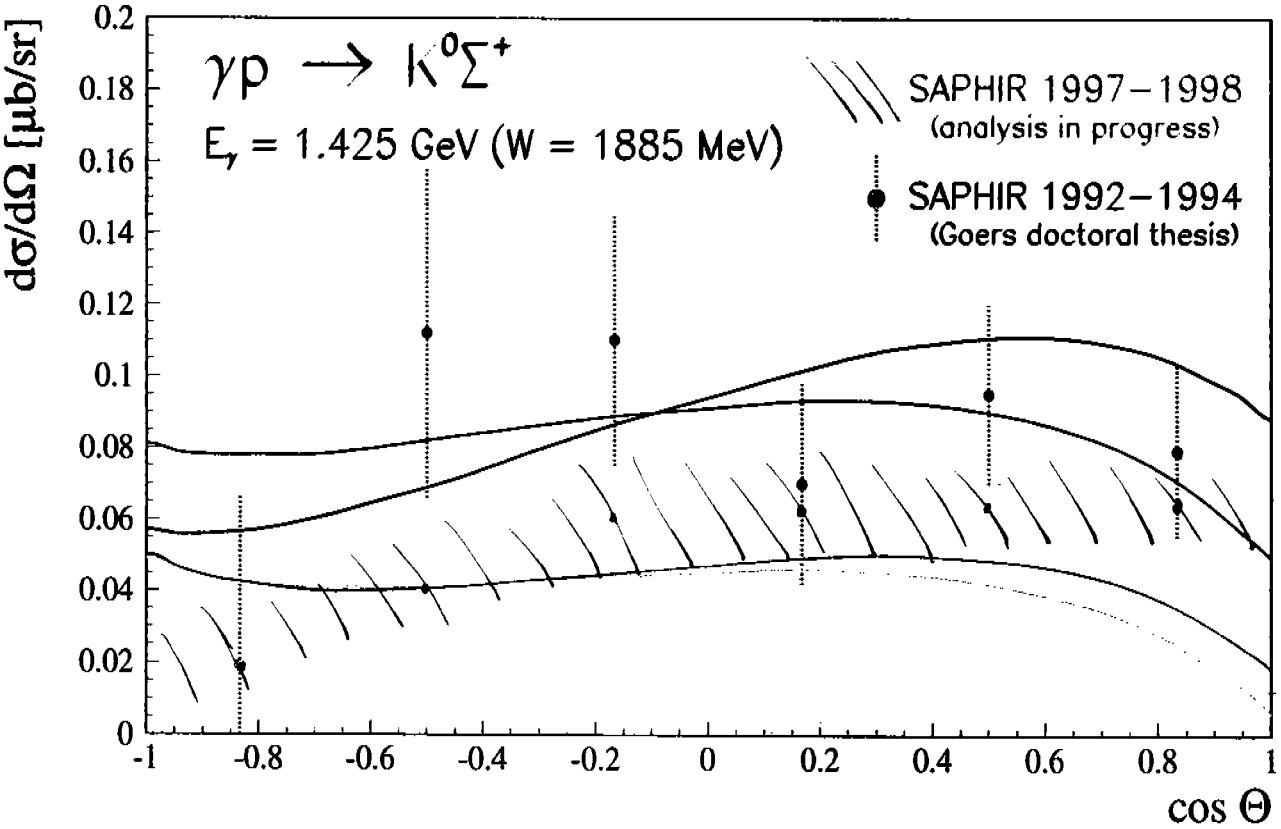
Total cross sections



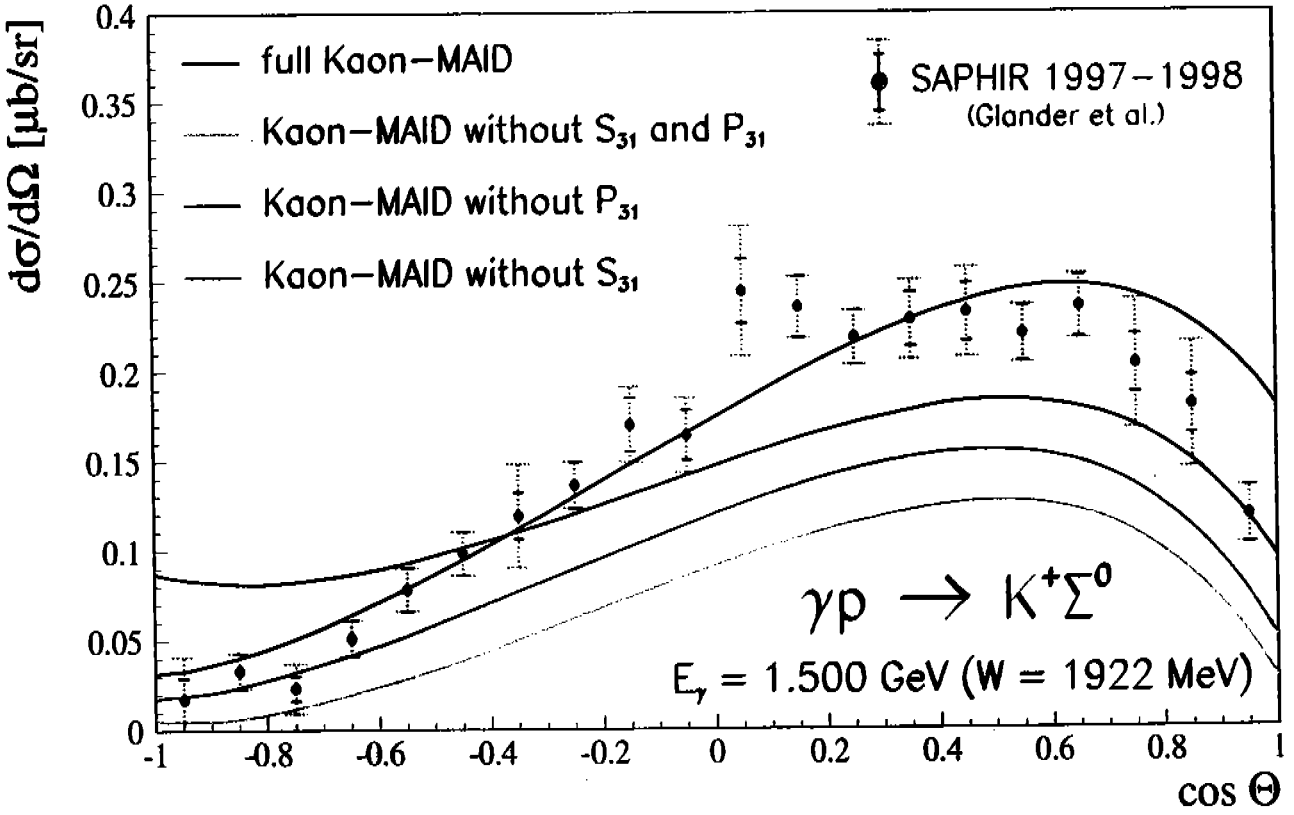


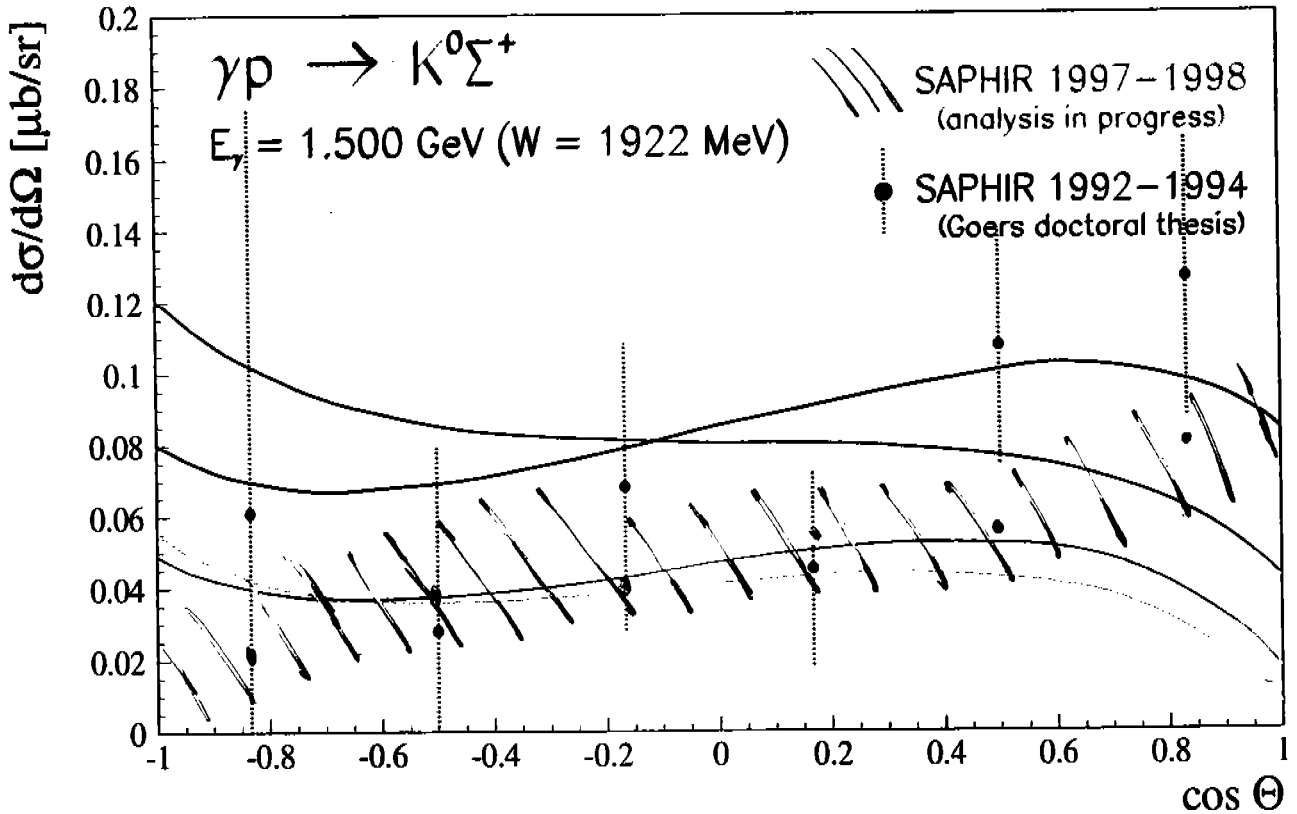
Differential cross sections





Differential cross sections





Summary

$\gamma p \to K^+\Lambda$ / $K^+\Sigma^0$:

- **differential cross sections measured over full angular range with resolution improved by factors of 2 for E_γ and $cos\,\theta^{cms}_{K^+}$ both**
- **hyperon polarizations measured**
- **photon energy extended from 2.0 to 2.6 GeV**

$\longrightarrow$ **Interpretation still in progress**
(missing resonances ?)

$\gamma p \to K^0\Sigma^+$: **will help to constrain $K^+\Sigma^0$ in isobare models**

Other Kaon photoproduction reactions

- **Three body final states $K\,Y\,\pi$:**

  $\longrightarrow$ provide a good tool to study excited hyperon states

  $\gamma p \to K^+\Sigma^-\pi^+$: $\Sigma^0(1385)$,$\Lambda(1405)$,$\Lambda(1520)$,...

  $\longrightarrow$ differential cross sections !

  $\gamma p \to K^+\Lambda\pi^0$: **diff. c.s. for $\gamma p \to K^+\Sigma^0(1385)$ feasible**

- $\gamma p \to p K^+ K^-$:

  $\gamma p \to p\,\Phi$: **diffractive production of $s\bar{s}$-pair ?!**

  $\gamma p \to K^+\Lambda(1520)$: **total and differential cross sections and decay angular distributions**