Kaon electromagnetic production: constraints set by new data

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INTRODUCTION

MODELS

CONCLUSION

INTRODUCTION

- $\gamma + p \longrightarrow K^+ + \Lambda$
- good description of the elementary process
  → <u>hypernuclear calculations</u> [T. Motoba]
- analysis of the models: Adelseck-Bennhold, Adelseck-Wright, Adelseck-Saghai, Williams-Si-Colaneck, Saclay-Lyon, Kaon-MAID, and Regge in view of "new" data:
  Mohring et al [E93-018, Phys. Rev. C67(2003)055205] and Tran et al [SAPHIR(98), Phys. Lett. B445(1998)20] can be found in nucl-th/0305039
- latest data on $\frac{d\sigma}{d\Omega}$ and P for the photo-production

CLAS (J.W.C. McNabb et al) [nucl-ex/0305028]
SAPHIR (K.-H. Glander et al) [nucl-ex/0308025]

  – inconsistent at small θ_K

→ learn more about the reaction mechanism Are the models able to conform to the data?

Isobaric models:

- tree-level effective Lagrangian approach
- too many resonances: 20 - 30 [C. Bennhold]
- SU(3) symmetry limits: $-4.4 \lesssim g_{KN\Lambda}/\sqrt{4\pi} \lesssim -3.0$

  $0.8 \lesssim g_{KN\Sigma}/\sqrt{4\pi} \lesssim 1.3$

- crossing symmetry: $R_{\gamma\Lambda} = \Gamma(K^- p \to \gamma\Lambda)/\Gamma(K^- p \to \text{all})$

→ • structure of hadrons: hadronic form factors

× gauge invariance

→ method by Haberzettl; Davidson and Workman

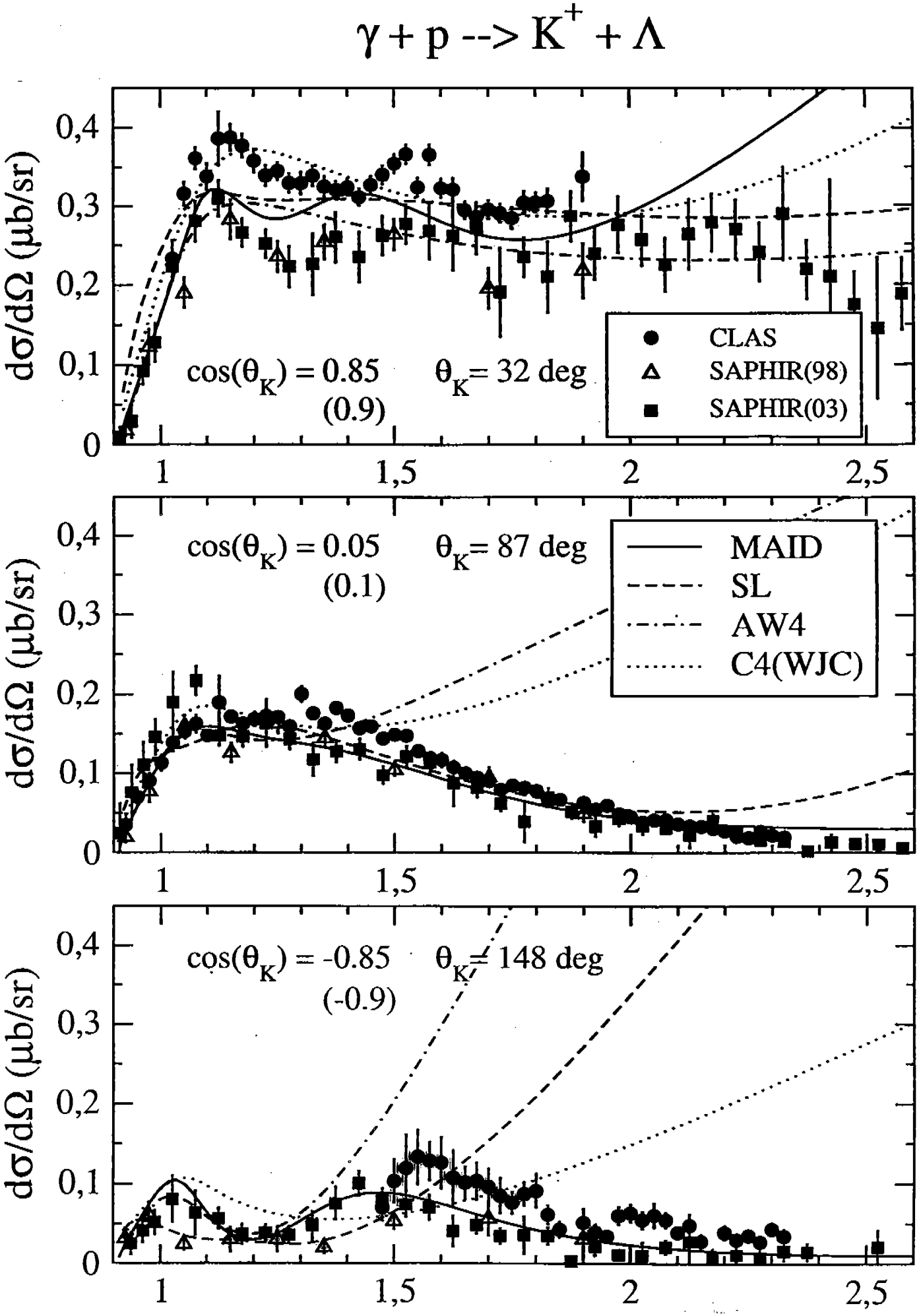
[Phys. Rev. C63 (2001) 025210]

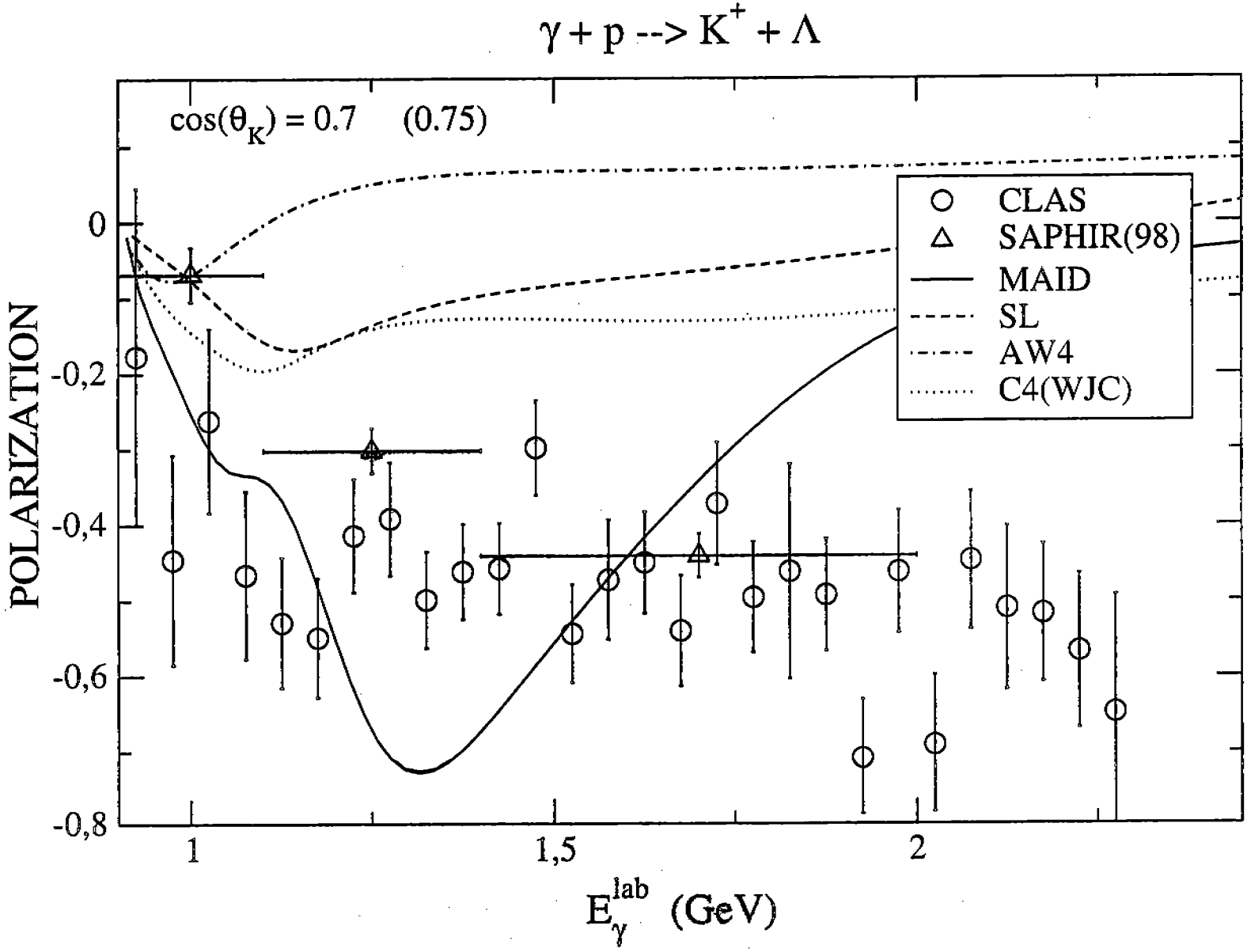
contact term: $F(s,u,t) = F_1(s) + F_2(u) + F_3(t) -$

$- F_1(s)F_2(u) - F_1(s)F_3(t) - F_2(u)F_3(t) + F_1(s)F_2(u)F_3(t)$

with

$$F_i(x) = \frac{\Lambda^4}{\Lambda^4 + (x - m^2)^2} \qquad (x = s, u, t)$$


γ + p --> K+ + Λ
dσ/dΩ (μb/sr)
0,4
0,3
0,2
0,1
0
1
1,5
2
2,5
cos(θK) = 0.85
(0.9)
θK = 32 deg
CLAS
SAPHIR(98)
SAPHIR(03)
cos(θK) = 0.05
(0.1)
θK = 87 deg
MAID
SL
AW4
C4(WJC)
cos(θK) = -0.85
(-0.9)
θK = 148 deg


γ + p --> K+ + Λ
cos(θK) = 0.7 (0.75)
CLAS
SAPHIR(98)
MAID
SL
AW4
C4(WJC)
POLARIZATION
0
-0,2
-0,4
-0,6
-0,8
1
1,5
2
Eγlab (GeV)

MODELS

Saclay-Lyon (SL) [David et al, Phys. Rev. C53(1996)2613]

- *no hadronic form factors*
- resonances

  SL: K*, K_1, N(1440)(P_{11}), N(1720)(P_{13}), **N(1675)(D_{15})**,
  $\Lambda(1405)(S_{01})$, $\Lambda(1670)(S_{01})$, $\Lambda(1810)(P_{01})$, **$\Sigma(1660)(P_{11})$**

  SLA: K*, K_1, N(1720)(P_{13}),
  $\Lambda(1405)(S_{01})$, $\Lambda(1670)(S_{01})$, $\Lambda(1810)(P_{01})$, $\Sigma(1660)(P_{11})$

- coupling constants are re-fitted to $d\sigma/d\Omega$

  CLAS: SL(CL) (918 data points)

  SAPHIR(03): SL(S03) (701 data points)

  with *SU(3) limits* for $g_{K\Lambda N}$ and $g_{K\Sigma N}$

	SL(CL)	SL(S03)	SLA(CL)	SLA(S03)
χ^2:	273 → 2.23	171 → 3.23	281 → 3.65	171 → 5.74

– moderate change of the coupling constants with the exception of:

  SL(CL): N(1440), N(1675) $-0.02 \longrightarrow 2.40 \pm 0.8$

  SLA(CL): N(1720)

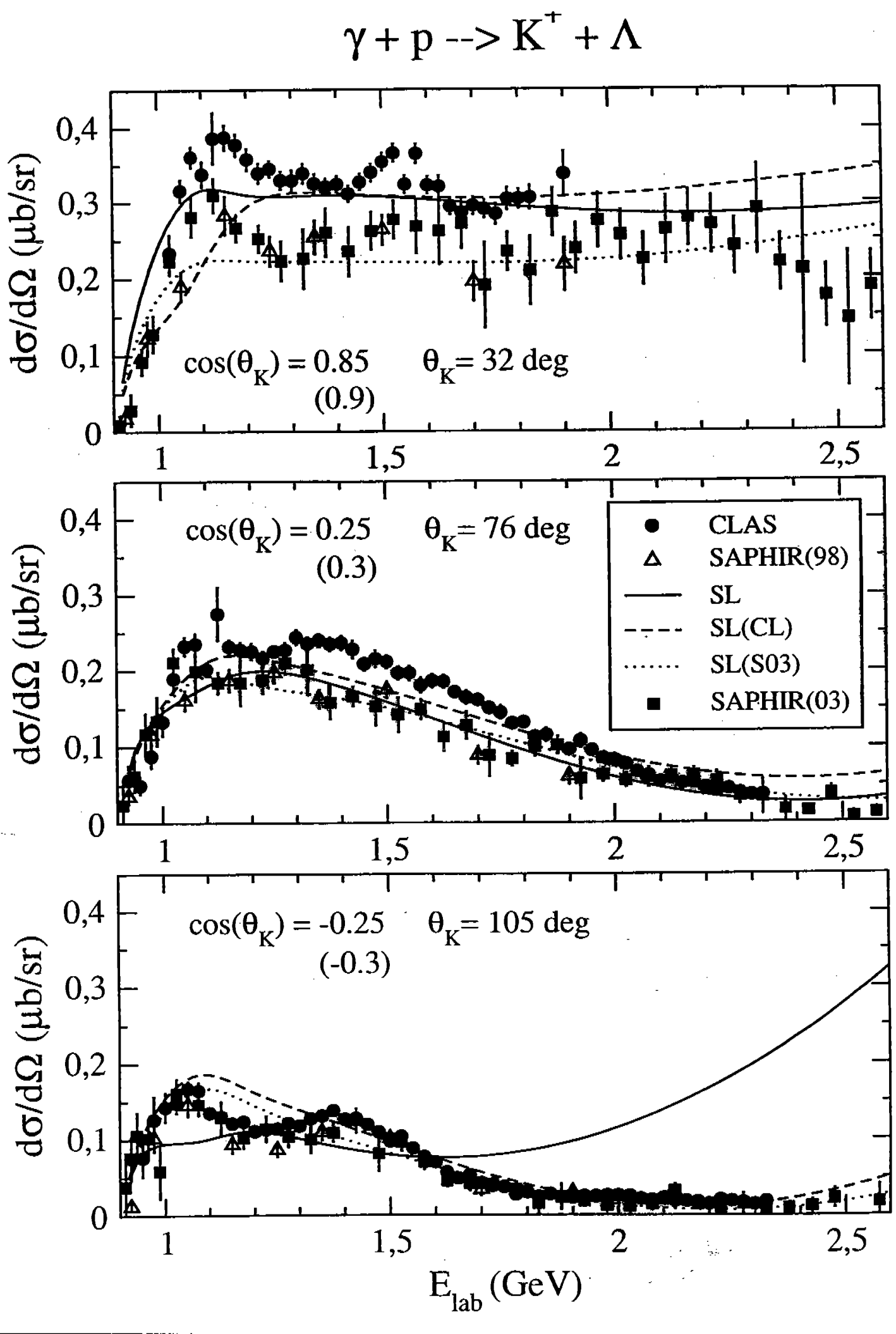
  SL(S03): N(1440), Λ(1810) $-1.96 \longrightarrow 6.26 \pm 15.$!

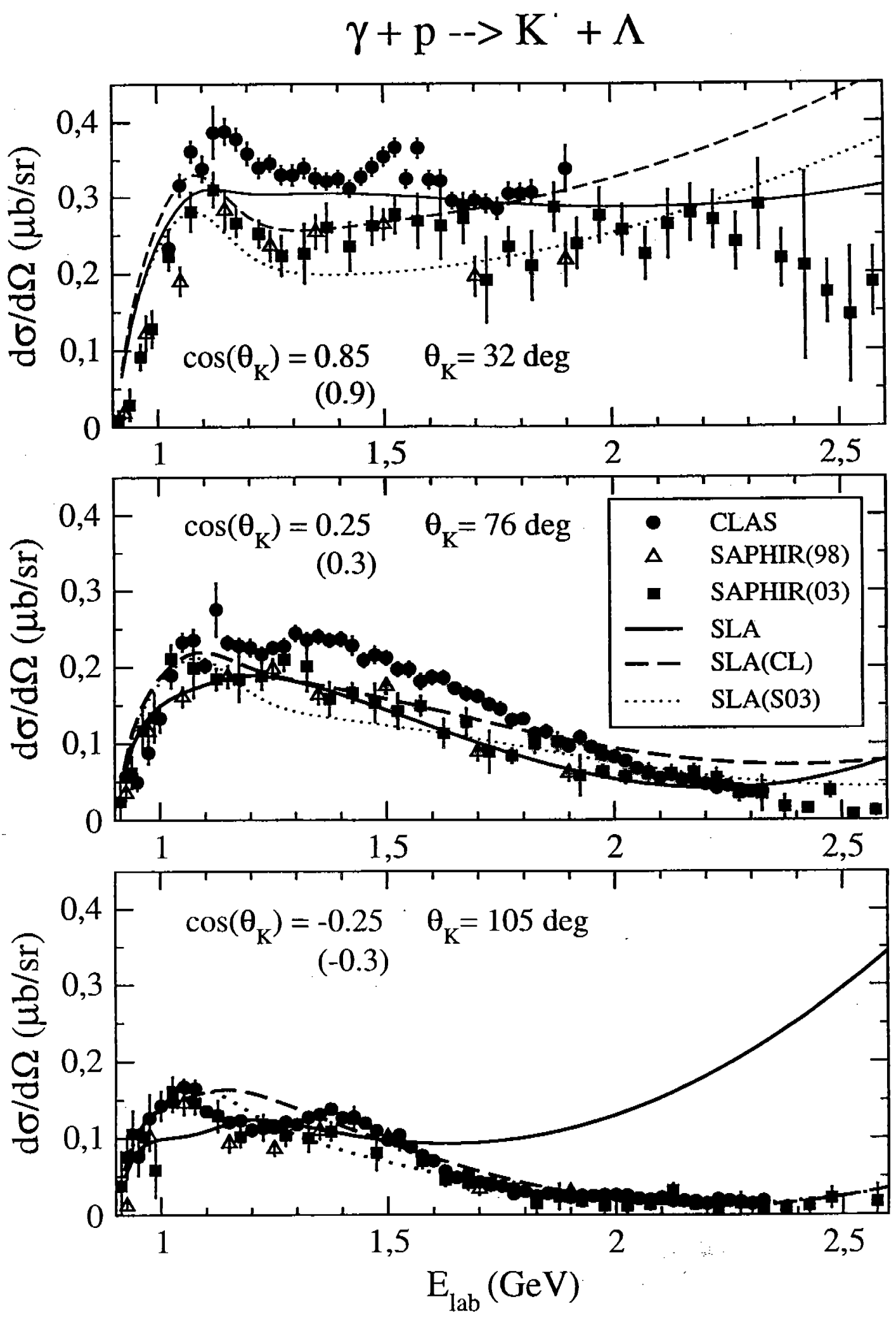
  SLA(S03): $\Lambda(1405)$, $\Lambda(1670)$, $\Lambda(1810)$

– **big errors** for the hyperon resonances

  → *the u-channel contributions are not well determined*

– large non resonant contribution


γ + p --> K+ + Λ
dσ/dΩ (μb/sr)
cos(θK) = 0.85 (0.9)
θK = 32 deg
cos(θK) = 0.25 (0.3)
θK = 76 deg
cos(θK) = -0.25 (-0.3)
θK = 105 deg
CLAS
SAPHIR(98)
SL
SL(CL)
SL(S03)
SAPHIR(03)
Elab (GeV)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CLAS
SAPHIR(98)
SAPHIR(03)
SLA
SLA(CL)
SLA(S03)
Elab (GeV)

Saclay-Lyon type model

- K*, K_1, N(1440)(P_{11}), N(1720)(P_{13}), Λ(1670)(S_{01}), Λ(1810)(P_{01})
- *hadronic form factors* of Davidson and Workman (Λ_1)
- g's and Λ_1 are fitted to CLAS data ($d\sigma/d\Omega$)
- SU(3) limits for $g_{K\Lambda N}$ and $g_{K\Sigma N}$; $0.6 \leq \Lambda_1 \leq 2.0$

results in $\boxed{\chi^2 = 2.08, \quad \Lambda_1 = 0.96 \pm 0.3 \text{ GeV}}$

big errors of g's for

N(1440): -0.64 $\pm$ 5.2

Λ(1670): 3.32 $\pm$ 7.6

Λ(1810): -10.0 $\pm$ 18.7

other choice of hyperon resonances leaves the uncertainty of g's big

$\Lambda(1810) \rightarrow \Lambda(1600)$: $\boxed{\chi^2 = 1.66, \quad \Lambda_1 = 1.1 \pm 0.3 \text{ GeV}}$

Λ(1670): 5.79 $\pm$ 16.5

Λ(1600): -10.0 $\pm$ 14.9

Kaon-MAID type model (or Janssen et al.)

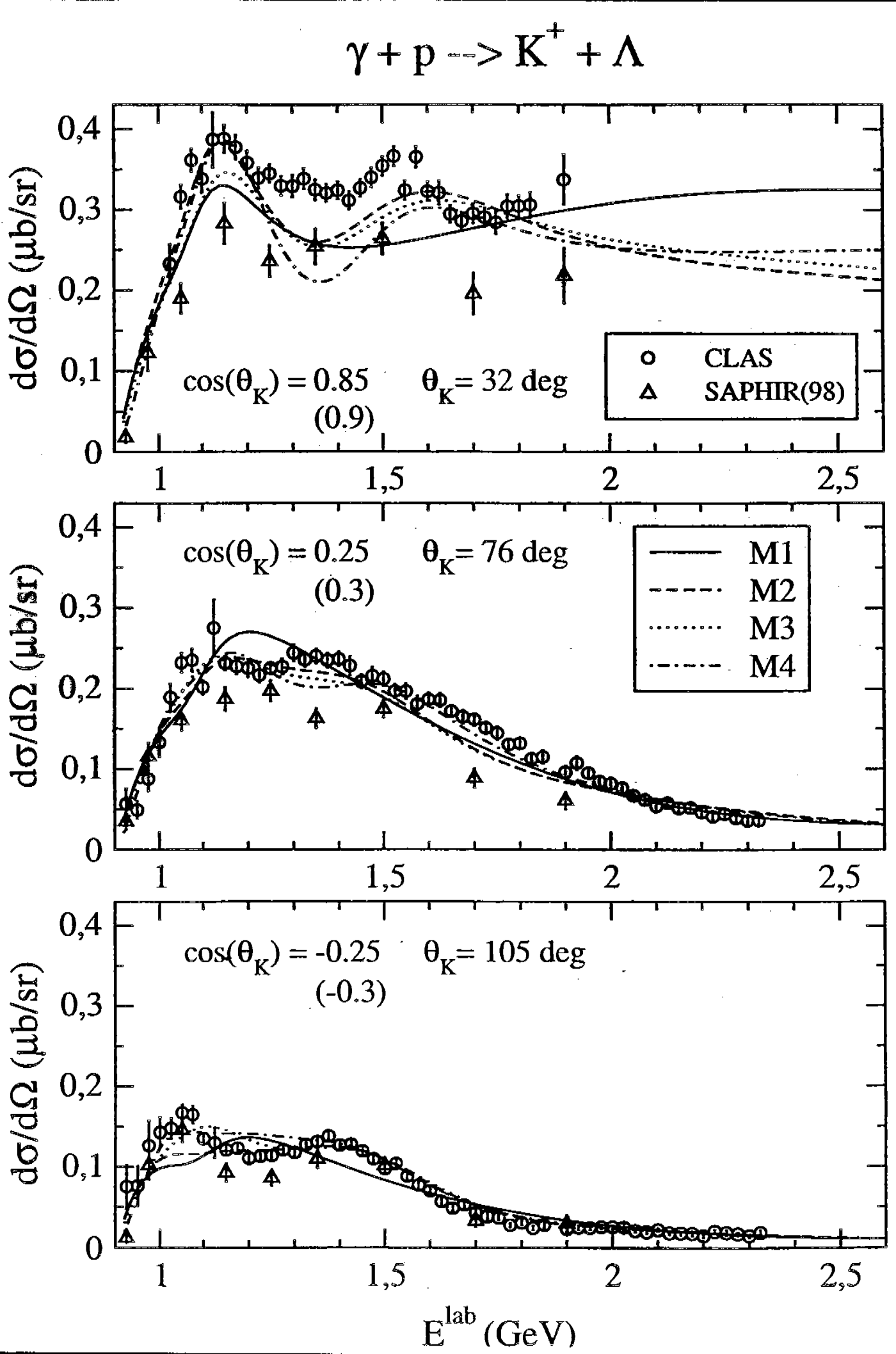
- *hadronic form factors* of Davidson and Workman (Λ_1)
- g's and Λ_1 are fitted to CLAS data ($d\sigma/d\Omega$)
- SU(3) limits for $g_{K\Lambda N}$ and $g_{K\Sigma N}$; $0.6 \leq \Lambda_1 \leq 2.0$

Coupling constants:

Model:	M1	M2	M3	M4
K*	0.14 (0.6)	-0.01 (0.4)	-0.02 (0.6)	-0.20 (0.4)
	0.50 (1.0)	0.27 (0.9)	0.24 (0.7)	0.21 (0.8)
K_1	-0.38 (0.7)	0.28 (1.3)	0.30 (1.7)	———
	-2.14 (1.9)	-0.64 (1.8)	-0.69 (2.0)	———
N*(1650)	0.12 (0.1)	0.14 (0.1)	0.13 (0.1)	-0.14 (0.1)
N*(1710)	0.21 (1.0)	0.25 (1.2)	———	———
N*(1720)	-0.11 (0.2)	-0.10 (0.2)	-0.13 (0.1)	0.16 (0.1)
	-0.55 (1.0)	-0.63 (1.3)	-0.88 (0.6)	0.92 (0.5)
$D_{13}(1895)$	———	-0.32 (0.8)	-0.22 (0.9)	-0.79 (0.6)
	———	-0.31 (0.5)	-0.25 (0.5)	-0.58 (0.3)
Λ_1 (GeV)	0.89 (0.2)	0.88 (0.2)	0.87 (0.2)	0.80 (0.1)
χ^2	1.37	0.83	0.92	0.99

Addition of $\Lambda^*(1600)$ and $\Lambda^*(1670)$ into the M1 model results in $\boxed{\chi^2 = 1.25 \quad \text{and larger} \quad \Lambda_1\text{: } 1.00 \pm 0.06 \text{ GeV}}$

but $g_{\Lambda(1670)} = 1.94 \pm 3.2$ and $g_{\Lambda(1600)} = -10.0 \pm 16.0$!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M2
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M4
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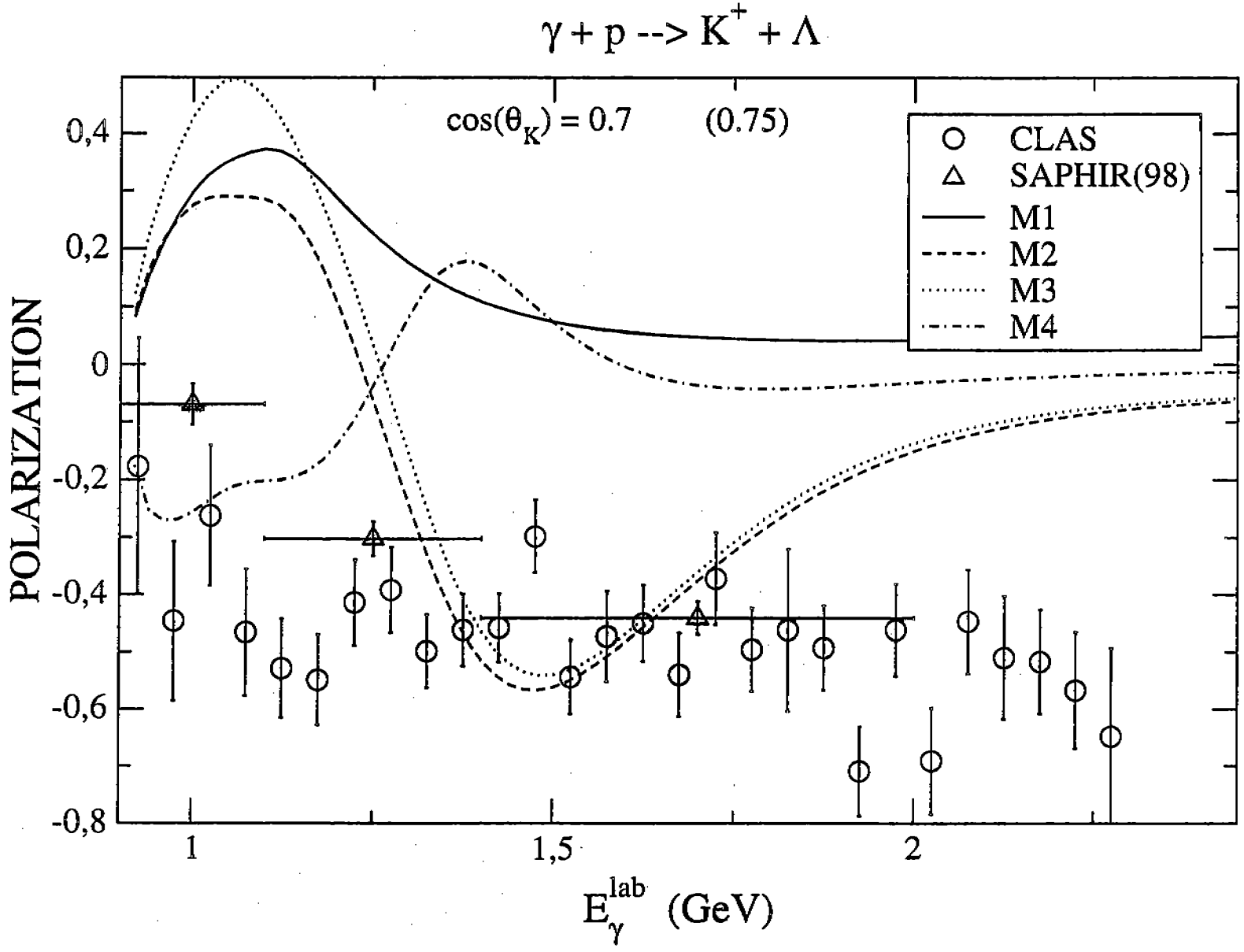
E lab (GeV)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SAPHIR(98)
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M2
M3
M4
POLARIZATION
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0,2
0
-0,2
-0,4
-0,6
-0,8
1
1,5
2
Eγlab (GeV)

CONCLUSIONS (preliminary)

- "old" models (SL) being re-fitted can describe a global behaviour of $\frac{d\sigma}{du}$ up to 2.4 GeV (also for large θ_K) but cannot describe details of the data

- contributions from hyperon resonances are not well determined with the photo-production $\frac{d\sigma}{du}$

- the "missing" resonance $D_{13}(1895)$ is important for description of details of the structure of $\frac{d\sigma}{du}$; important also for polarizations