

PWA of K^+N Scattering Data and Exotic Z^+ Resonances

R.A. Arndt, I.I. Strakovsky, R.L. Workman

Dept. of Physics, Center for Nuclear Studies
The George Washington University
Washington, D.C., 20052

- Historical Perspective
- Recent and Preliminary experimental results:
Evidence for an $S = +1$ Resonance
- The VPI KN Analysis - a tool
to search for narrow states

Supported by

The U.S. Department of Energy
Jefferson Lab

and

The George Washington University

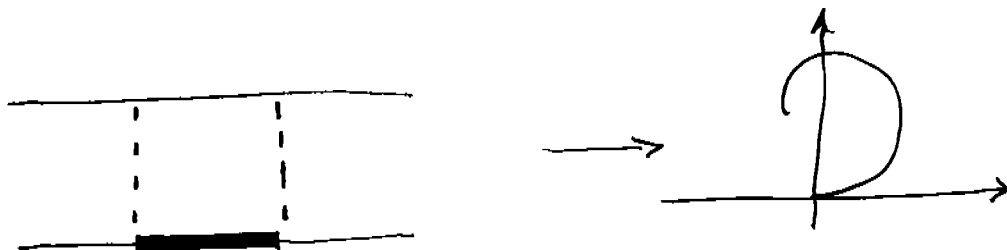
Some History of Exotic States

(PDG Review 1984)

- Z_0 , Z_1 ($S=+1$)
 $Z_0(1780) P_{01}$ width 300-800 MeV
- Dibaryons ($B=2$)
 $^1D_2, ^3F_3$
 $^1D_2(2170)$ width 100-200 MeV

(PDG Review 2002)

- Z^* and Dibaryon sections gone
Non-qqq (1 paragraph)
- Broad states assumed pseudo-resonances



Evidence for an $S = +1$ State

(Experimental)

- $\gamma^{12}C \rightarrow K^+ K^- X$ (SPRING-8)
 $M = 1540 \pm 10 \text{ MeV}$ $\Gamma < 25 \text{ MeV}$
- $K^+ Xe \rightarrow K^0 p Xe'$ (ITEP)
 $M = 1539 \pm 2 \text{ MeV}$ $\Gamma < 9 \text{ MeV}$
- $\gamma d \rightarrow K^+ K^- pn$ (JLab)
 $M = 1542 \pm 5 \text{ MeV}$ $\Gamma < 21 \text{ MeV}$
- $\gamma p \rightarrow \pi^+ K^- K^+ n$
 $M = 1537 \text{ MeV}$ $\Gamma < 31 \text{ MeV}$
- $\gamma p \rightarrow n K_s^0 K^+$ (SAPHIR)
 $M = 1540 \pm 4 \pm 2 \text{ MeV}$ $\Gamma < 25 \text{ MeV}$
- $\nu CC, \bar{\nu} CC$ on p, d, Ne (ITEP)
 $M = 1533 \pm 5$ $\Gamma < 20 \text{ MeV}$
- $eD \rightarrow K_s^0 p X$ (HERMES) *prelim.*
 $M = 1526 \pm 2 \pm 2$ $\Gamma < 18 \text{ MeV}$

Limits on an $S = +1$ State

(Phenomenological)

- Nussinov hep-ph/0307357
 $\Gamma < 6 \text{ MeV}$
- GW Group nucl-th/0308012
 $\Gamma < 1\text{-}2 \text{ MeV}$
- Gothe, Nussinov hep-ph/0308230
 $\Gamma < 3\text{-}6 \text{ MeV}$
($\Gamma \lesssim 1 \text{ MeV}$) R.N. Cahn (P.C.)
- Haidenbauer, Grein hep-ph/0309234
 $\Gamma < 5 \text{ MeV}$

Differ essentially from the experimental determinations. Based on seeing NOTHING in the existing K^+d data.

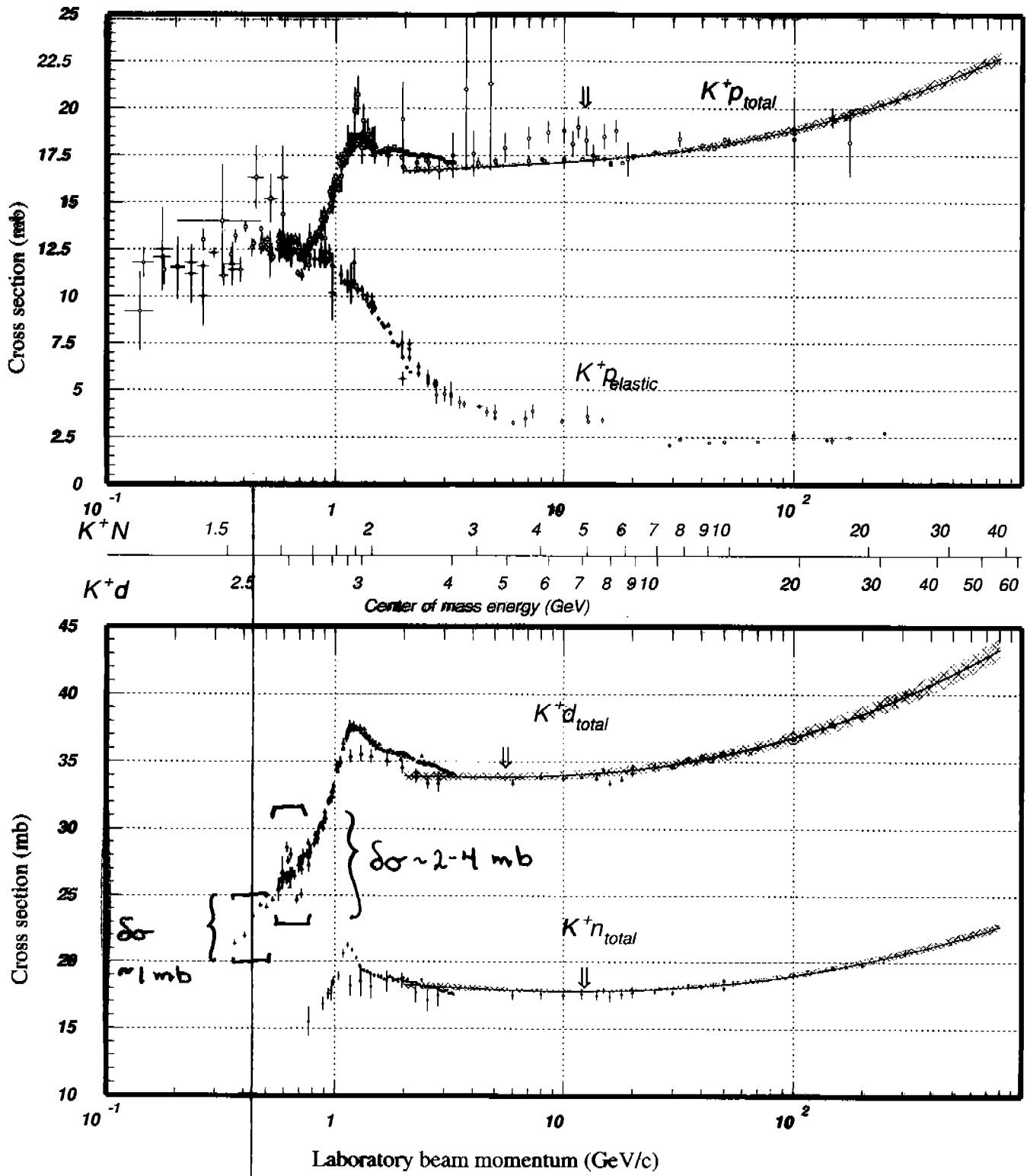


Figure 39.16: Total and elastic cross sections for K^+p and total cross sections for K^+d and K^+n collisions as a function of laboratory beam momentum and total center-of-mass energy. Corresponding computer-readable data files may be found at <http://pdg.lbl.gov/xsect/contents.html> (Courtesy of the COMPAS Group, IHEP, Protvino, Russia, August 2001.)

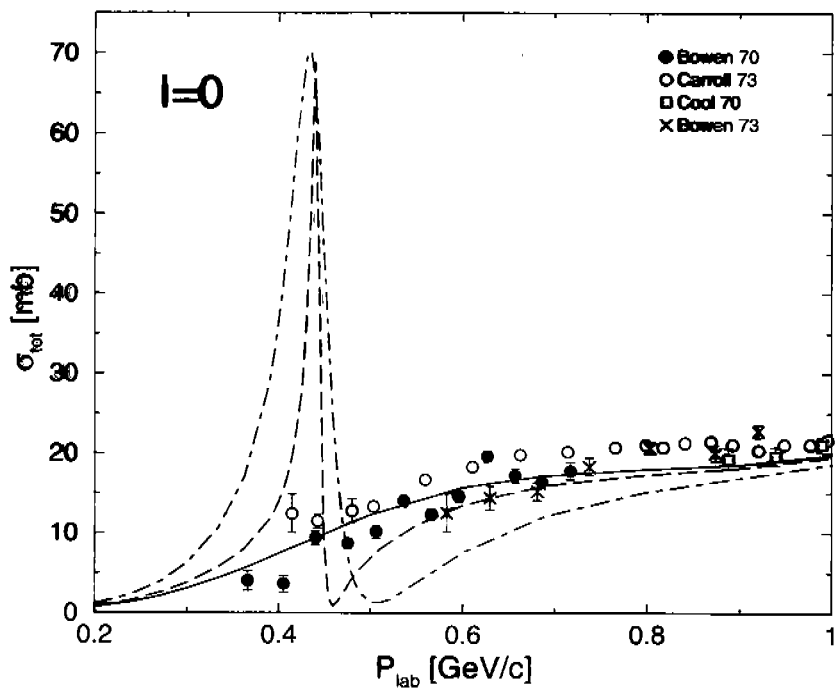
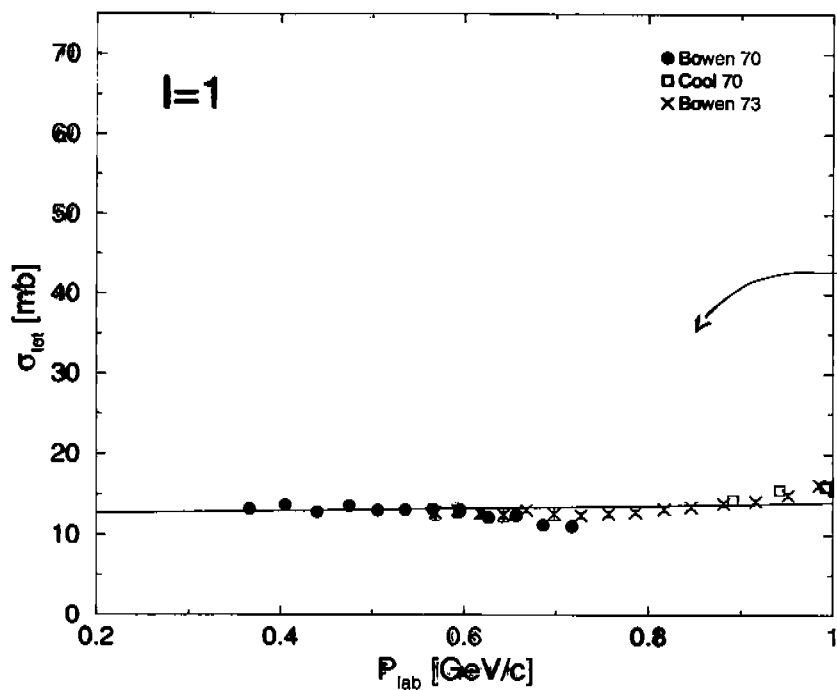


Fig. 2

" $\theta [Z^+(1540)]$ much narrower [than 5 MeV]"
or much closer to threshold

Data Near the $\Theta(1540)$

Numerous K^+p , K^+D expt, angular distn
in W_{CM} range 1520 - 1555 MeV

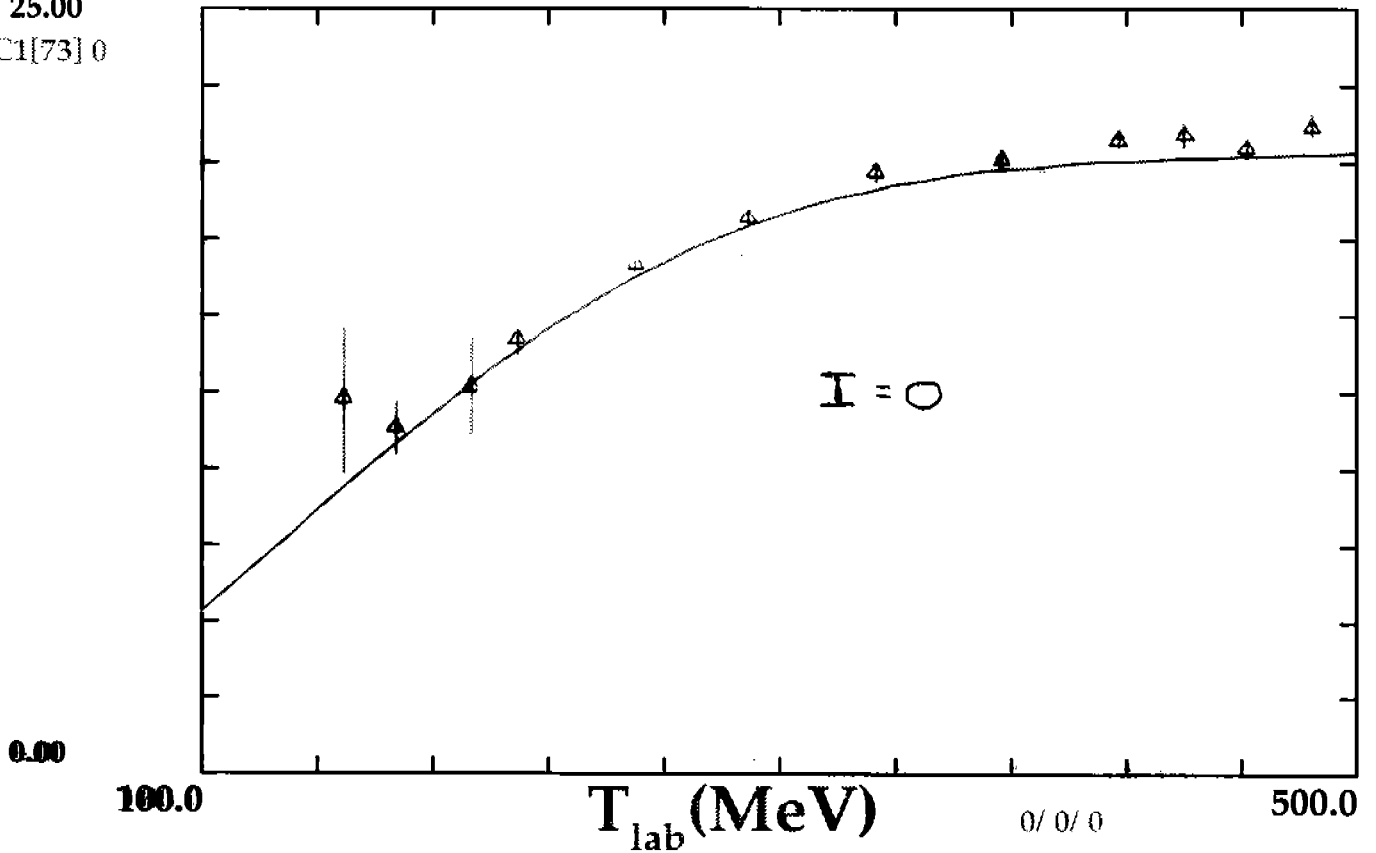
- K^+D data
 - K^+N $I=0$ σ_T (from K^+D)
 - $K^+D \rightarrow K^+D$ (coherent) $d\sigma/d\Omega$
 - $K^+D \rightarrow K^0p(p)$ $d\sigma/d\Omega$
 - $K^+D \rightarrow K^+n(p)$ $d\sigma/d\Omega$

- K^+D σ_T not used

- Details: J.S. Hyslop, Ph.D. thesis
J.H. Hyslop et al., PRD46, 961 (92)

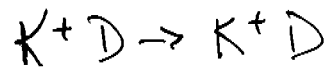
Plotted data is for ACM = 0.00 to ACM = 0.00
KI=0 SGT ACM = 0.00 UN-Normalized

25.00
△ C1[73] 0



SP92 0-2650(100) K+P = 4871/3663 I0 = 3172 1746 PRMS = [6
KN941 DATA VPI&SU MODIFIED BY IHS 1990 [KNDATBAS]

↑
W_{cut} ~ 1730 MeV

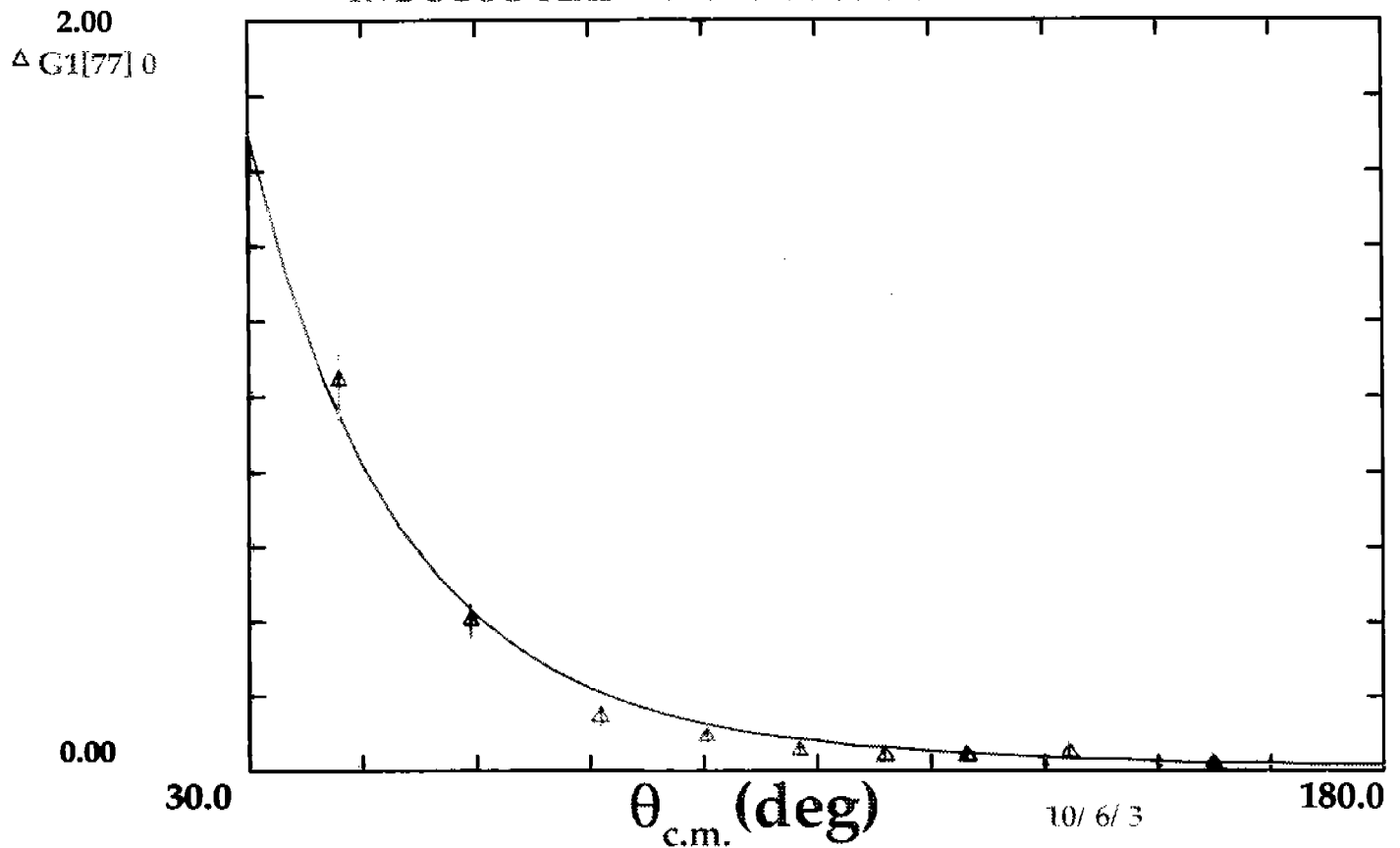


$$W_{CM} \sim 1550 \text{ MeV}$$

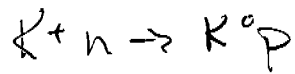
Deut Form= 1 P1c,P2c= 0.100 0.250 GeV

Plotted data is for TLAB= 187.00 to TLAB= 189.00

K+DC DSG TLAB= 188.00 UN-Normalized



SP92 0-2650[1100] K+P = 4871/3663 I0= 3172/1746 PRMS=[6
KN941 DATA VPI&SU MODIFIED BY JHS 1990[KN DATBAS]



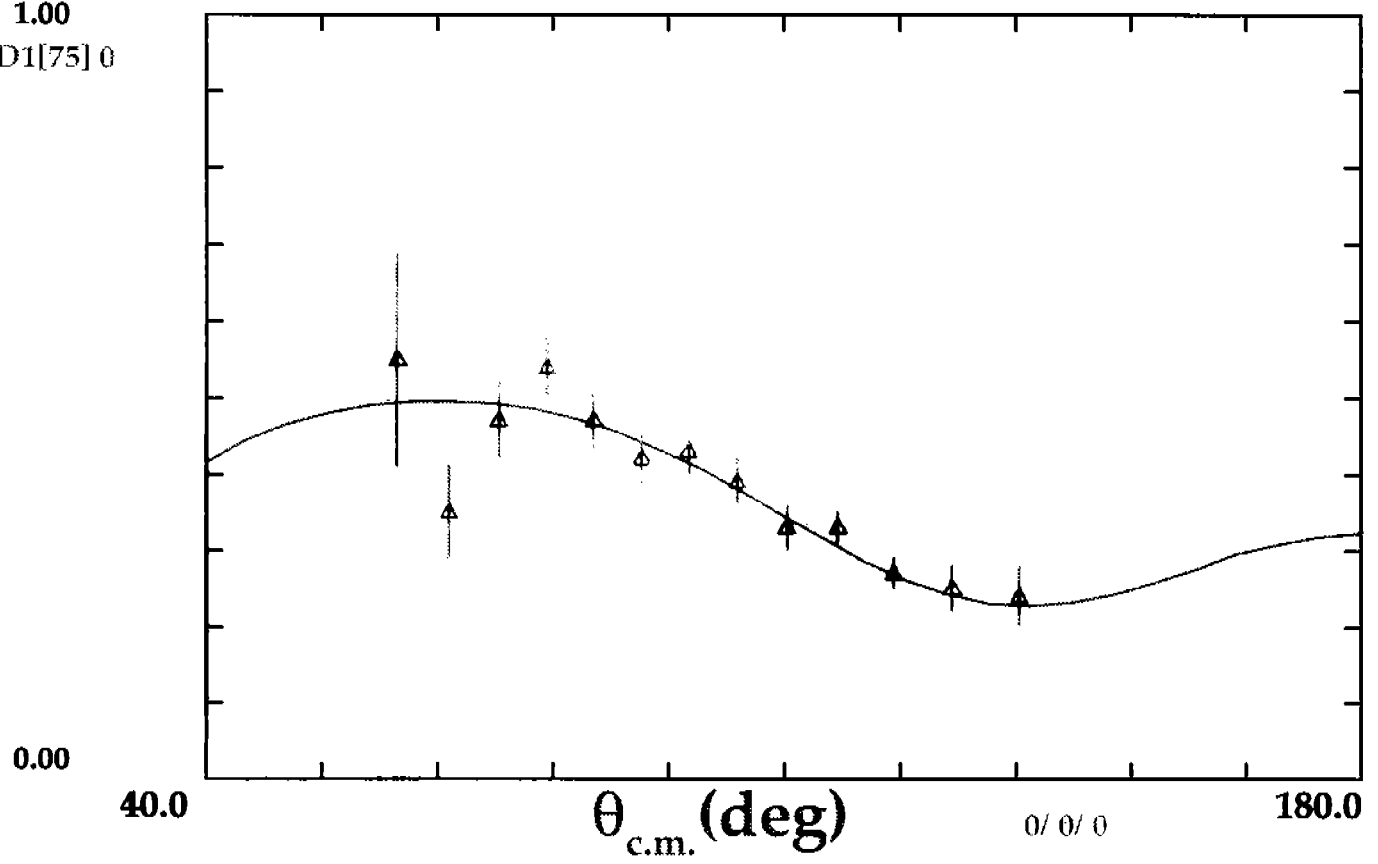
$W_{cm} \sim 1535 \text{ MeV}$

Deut Form= 1 P1c,P2c= 0.000 0.280 GeV

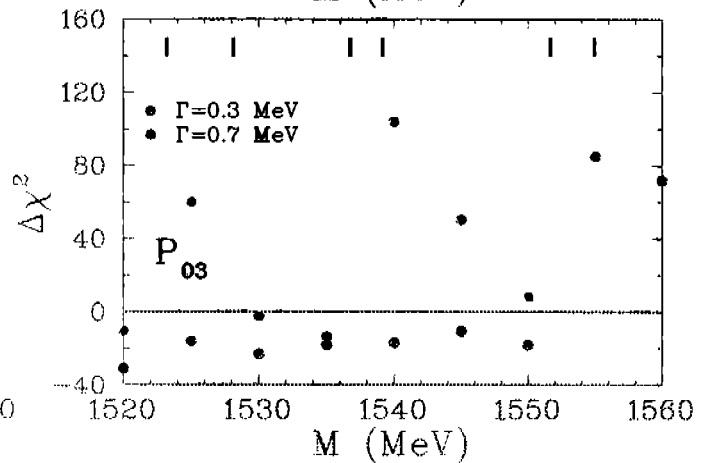
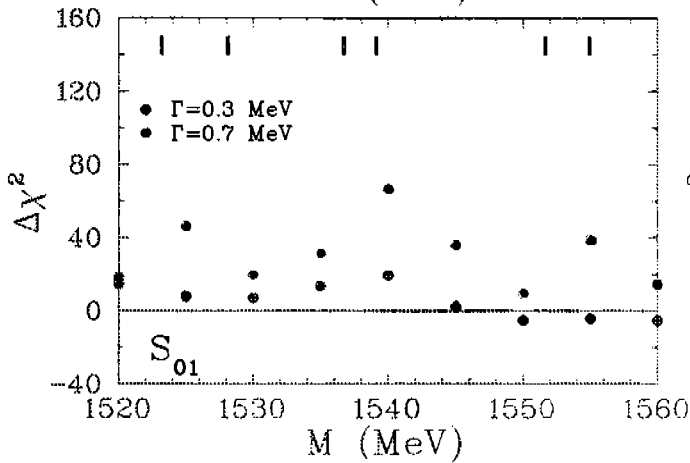
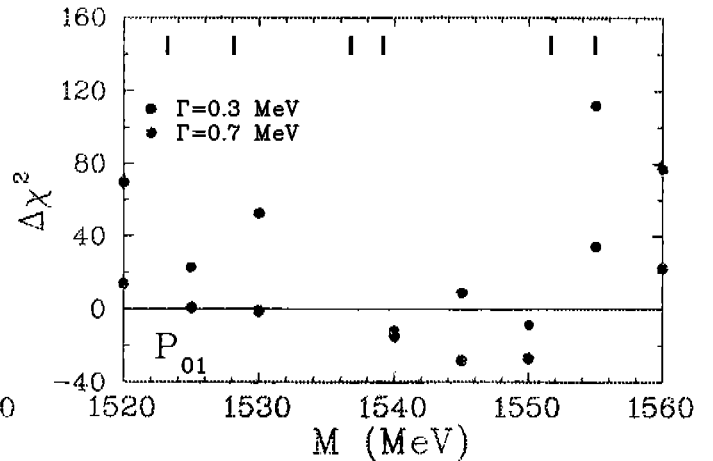
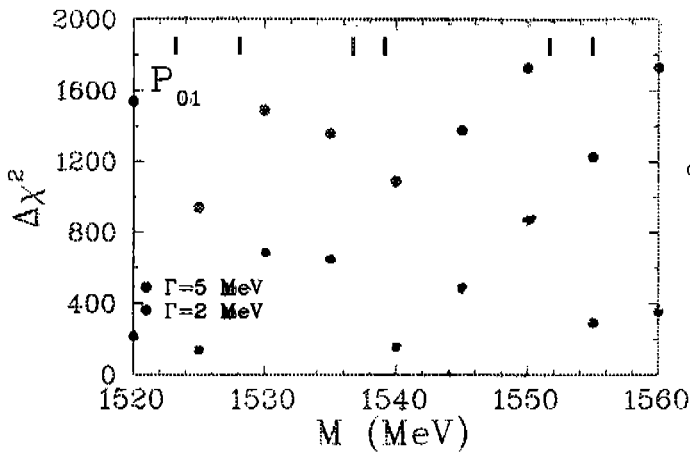
Plotted data is for TLAB= 163.00 to TLAB= 164.00

K+NX DSG TLAB= 163.50 UN-Normalized

1.00
△ D1[75] 0



SP92 0-2650[1100] K+P = 4871/ 3663 I0= 3172/ 1746 PRMS=[6
KN941 DATA VPI&SU MODIFIED BY JHS 1990[KNDATBAS]



- product S-matrix approach

$$- T_{\text{Res}} = \frac{r/2}{w_R - w - i\Gamma/2}$$

- added background allowed near w_R

SPa2 fit: $I=0$ $T_{\text{Lab}} \rightarrow 1.1 \text{ GeV}$ $\chi^2_{\text{data}} = \frac{3198}{1746}$

$I=1$ $T_{\text{Lab}} \rightarrow 2.65 \text{ GeV}$ $\chi^2_{\text{data}} = \frac{4872}{3663}$

Conclusions on $\Theta(1540)$

- γ, ν induced: $\Gamma < 20$ MeV
- K^+ (ITEP) $\Gamma < 9$ MeV
Conservative - lower estimates exist
- K^+N data (older) $\Gamma < 2$ MeV
Several consistent estimates at this level
- Difficult to do better than this
(... but we are trying)