Comment on the Cross Sections of the S, T, and U Mesons

W. Kienzle
CERN, Geneva, Switzerland
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Absolute cross-section measurements with the CERN-IHEP Boson Spectrometer in the reaction $\pi^- p \to X^- p$ at 11 and 25 GeV/c indicate that the S, T, U cross sections obtained with the old missing-mass spectrometer (1965/66) at 12 GeV/c have been overestimated by a factor of ~ 4. While this does not affect the statistical significance of the peaks, it is important for any comparison with other experiments.

In 1971 we observed with the CERN-IHEP Boson Spectrometer (CIBS) in the reaction $\pi^- p \to X^- p$ at 25 GeV/c that the missing-mass spectra are without structure[1] in the "S, T, U region" (1.8–2.5 GeV)^2 and above. In order to understand the absence of the S, T, U peaks in the new data, we have compared the published cross sections of the old missing-mass spectrometer (MMS) of 1965/66[2] with those of the CIBS. The comparison is done by using the differential cross section $\Delta\sigma/\Delta M\Delta t$ for the smooth physical background at a mass of ~2 GeV.

I. THE MMS (1966) DATA, $\pi^- p \to X^- p$ AT 12 GeV/c

(a) *The "S" peak* ($M \approx 1.9$ GeV). This is quoted in Ref. 2 as having a differential cross section $\Delta\sigma/\Delta t = 35\ \mu\text{b/GeV}/c)^2$ in the momentum transfer interval $0.22 < |t| < 0.36$ (GeV/c)^2. Since there are 226 events contained in the peak, the cross section per event is $(\Delta\sigma/\Delta t)_{\text{event}} = 0.16\ \mu\text{b}/(\text{GeV}/c)^2$. The S peak appears only in the decay mode $X^- \to 3$ charged tracks (+neutrals).[3] In order to obtain the quantity $\Delta\sigma/\Delta M\Delta t$ for *all* missing-mass events at the mass of the S, we add the subspectra for the different decay multiplicities (see Ref. 4, Fig. 1) and find a background level of 680 events inside one mass bin of 10 MeV.

Therefore[5]

$$\frac{\Delta\sigma}{\Delta M\Delta t} = 10.5\ \text{mb}/(\text{GeV}/c)^2\,\text{GeV} \quad \text{at} \begin{cases} M = 1.9\ \text{GeV} \\ |\bar{t}| = 0.29\ (\text{GeV}/c)^2. \end{cases}$$

(b) *The "T" and "U" region* (2.2–2.4 GeV). Applying the same procedure to Ref. 1 (Table I and Figs. 2 and 3) leads to

$$\frac{\Delta\sigma}{\Delta M\Delta t} = 12.2\ \text{mb}/(\text{GeV}/c)^2\,\text{GeV} \quad \text{at} \begin{cases} M = 2.3\ \text{GeV} \\ |\bar{t}| = 0.29\ (\text{GeV}/c)^2. \end{cases}$$

This number can only be considered as a rough check of (a), since the spectrum is rising with increasing mass.

II. THE CIBS (1971) DATA, $\pi^- p \to X^- p$ AT 11 AND 25 GeV/c

(a) *The 11-*GeV/c *run*. In the beginning of 1970, before moving to Serpukhov, data were taken[6] with the CIBS at CERN at 11 GeV/c, in the mass interval from 1 to 2 GeV.[7] Since the full acceptance of the spectrometer covered also the "S" region, those data can be used for a comparison with the MMS cross sections. From the 11-GeV/c data where all parameters (acceptance, efficiencies, etc.) are known, we obtain

$$\frac{\Delta\sigma}{\Delta M\Delta t} = 2.7\ \mu\text{b}/(\text{GeV}/c)^2\,\text{GeV per event}$$

for

$$0.17 < |t| < 0.33\ (\text{GeV}/c)^2.$$

With a background level of 1240 events per bin of 10 MeV we get

$$\frac{\Delta\sigma}{\Delta M\Delta t} = 3.3\ \text{mb}/(\text{GeV}/c)^2\,\text{GeV} \quad \text{at} \begin{cases} M = 1.9\ \text{GeV} \\ |\bar{t}| = 0.25\ (\text{GeV}/c)^2. \end{cases}$$

If we scale[8] this to the $|\bar{t}| = 0.29$ (GeV/c)^2 of the S (MMS) and further correct for the energy difference (11 → 12 GeV/c) using $\Delta\sigma/\Delta M\Delta t \sim 1/p_{\text{lab}}$ (from CIBS data) we obtain finally

$$\frac{\Delta\sigma}{\Delta M\Delta t} = 2.5\ \text{mb}/(\text{GeV}/c)^2\,\text{GeV} \quad \text{at} \begin{cases} M = 1.9\ \text{GeV} \\ |\bar{t}| = 0.29\ (\text{GeV}/c)^2. \end{cases}$$

(b) *The 25-*GeV/c *run*. This can be used as rough check of (a). From Fig. 4 of Ref. 1 we read

$$\frac{\Delta\sigma}{\Delta M \Delta t} = 1.2 \text{ mb}/(\text{GeV}/c)^2 \text{ GeV}$$

$$\text{at} \begin{cases} M = 1.9 \text{ GeV} \\ |\bar{t}| = 0.29 \ (\text{GeV}/c)^2 . \end{cases}$$

When scaled to 12 GeV/c with $\Delta\sigma/\Delta M\Delta t \sim 1/p_{\text{lab}}$ (from CIBS data at 25 and 40 GeV/c)

$$\frac{\Delta\sigma}{\Delta M \Delta t} \approx 2.5 \text{ mb}/(\text{GeV}/c)^2 \text{ GeV} .$$

III. CONCLUSIONS

Comparison of the differential cross section $\Delta\sigma/\Delta M\Delta t$ between the data of CIBS [2.5 mb/(GeV/c)^{2}GeV] and MMS [10.5 mb/(GeV/c)^{2}GeV] for similar conditions [M = 1.9 GeV, $|\bar{t}|$ = 0.29 (GeV/c^2, p_{inc} = 12 GeV/c] shows a discrepancy by a factor of ~*4* (estimated uncertainty ±1).

We believe that the correct cross sections are those of CIBS, for the following reasons:

(i) In the CIBS a large number of internal cross checks were possible due to a powerful decay spectrometer in the forward direction. In particular, correct absolute elastic cross sections were obtained.

(ii) In the MMS analysis, as far as it can be reconstructed now, the trigger efficiency (~20–30%) has been omitted when calculating the incident pion flux. The old MMS cross sections of Ref. 2 should therefore be corrected by the above factor.

While this does not change the statistical significance of the peaks, it is important for any comparison with other experiments (Ref. 9).

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[1]Y. M. Antipov *et al.*, Phys. Letters 40B, 147 (1972).

[2]M. N. Focacci *et al.*, Phys. Rev. Letters 17, 890 (1966).

[3]The S and T peaks appear only in this decay mode. Their significance would drop by a factor of ~0.7 in the total, i.e., pure missing-mass data and would thus have been marginal without a decay-sensitive system.

[4]G. Chikovani *et al.*, Phys. Letters 22, 233 (1966).

[5]For relative errors (≈ ±20%) see Ref. 2, Table 1.

[6]R. Baud *et al.*, The CERN-IHEP Boson Spectrometer, presented at the 2nd Philadelphia Conference on Meson Spectroscopy, 1970 (unpublished).

[7]The analysis of these data as regards the R and S peaks is not yet completed and will be published separately.

[8]Using $d\sigma/dt \sim e^{-b|t|}$ with $b = 6$ at $M = 2$ GeV (from CIBS data).

[9]Measurements of missing-mass (MM) spectra from $\pi^- p \to (\text{MM})^- p$ at 8, 11, 13.5, and 16 GeV, by D. Bowen, D. Earles, W. Faissler, D. Garelick, M. Gettner, M. J. Glaubman, B. Gottschalk, G. Lutz, J. Moromisato, E. J. Shibata, Y. W. Tang, E. von Goeler, and R. Weinstein, and H. R. Blieden, G. Finocchiaro, J. Kirz, and R. Thun, in *Experimental Meson Spectroscopy,* edited by A. H. Rosenfeld and K. W. Lai (American Institute of Physics, New York, 1972).

The necessity of the cross-section correction in the MMS data has been pointed out to members of Stony Brook-Northeastern experiment (communications to Professor M. Gettner at the Oxford Conference, April 1972, and also to Professor D. Garelick at the Philadelphia Conference, April 1972). It implies that the negative evidence of their experiment as regards the S, T, U peaks is not "six to ten standard deviations" as claimed by the authors, but *four* times less, i.e., ~2 standard deviations only.