coplanarity in the plane of scatter. You can measure these angles very accurately indeed in emulsion. We have gone very carefully into this question of contamination and we would say that even in our smallest angular interval the contamination from the source you mentioned was less than 2%.

WINZELER: We have measured at 24 GeV by two methods. First with a bubble chamber, and then with emulsions. Vienna and Berne measured this. We have had no indication of any real part in the scattering amplitude with measurements down to a transverse momentum of about 50 MeV/c. May I ask Dr. Chuvilo, what was your lowest transverse momentum measured in $p-p$ scattering?

CHUVILO: It is equal to about 60 MeV/c.

BURHOP: Just a brief comment on Dr. Winzeler's point. I read the preprint from Vienna and I got the impression that there was a correction factor of about 50% at the small angles; the events that we used were actually seen.

WINZELER: It is not very clearly expressed how they obtained the final result. The correction factor was in fact calculated, I think, from the normalization to the bubble chamber results at large angles. The emulsion result at small angles (which cannot be reached by bubble chambers) then indicates that there is no large real part.

MATTHEWS: In calculating the optical point, is it not true that you have to assume both that the amplitude is purely imaginary and that the singlet total cross-section and triplet total are equal, and is there any reason for this second assumption?

TAYLOR: I would like to ask Burhop what was the smallest angle of scattering that they measured.

BURHOP: The smallest angle in our interval is 4 milliradians.

MARQUIT: It is interesting to note that nearly all experiments using emulsion as a detector give forward scattering amplitudes above the optical point. This includes the scattering chamber experiments of Preston *et al.* at 3 GeV, the scattering chamber experiments at 6 GeV and 10 GeV reported here by Chuvilo, as well as the Dubna, Sofia and London perpendicular exposures at 2.8, 6, 8.5 and 19 GeV. The Warsaw group, using a perpendicular exposure at 23 GeV, also obtained indications of a forward scattering amplitude greater than the optical model (the elastic scattering cross-section, partially corrected for scanning loss and with Coulomb scattering subtracted was 12.7 ± 2.6 mb). On the other hand, the experiments with counters and bubble chambers used as detectors tend to give agreement with the optical point. This difference between techniques most certainly warrants very careful study.

FENYVES: I would like to mention simply that some measurements on pion-proton elastic scattering at 7 GeV which have been carried out in Warsaw and in Budapest have shown very good agreement with the calculation of Domokos based on the asymptotics of Regge type.

WINZELER: May I mention that there is a measurement from 1959 or 1960 made by Preston *et al.* on proton-proton elastic scattering using a liquid hydrogen target, and then emulsion as detector but not as target, at 3 GeV. They do not obtain a real part at very small angles, and they conclude that it has to be smaller than 10%.

CHARGE EXCHANGE CROSS SECTION IN $\pi-p$ COLLISIONS AT 6 AND 18 GeV/c

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The Ecole Polytechnique one-metre heavy liquid bubble chamber was exposed at the CERN PS to 6, 11 and 18 GeV/c π^- beams. 35 000, 10 000 and 30 000 pictures respectively containing approximately 4 pions per picture were taken. The liquid used was a mixture of 86% propane and 14% Freon CF_3Br, by volume. The density of the liquid was 0.55, its radiation length 52 cm.

1. CHARGE-EXCHANGE CROSS-SECTIONS IN π—p COLLISIONS

The Okun-Pomeranchuk theorem predicts [1] that the cross-section for charge-exchange of π^- on p should tend to zero with increasing energy. At 1.14 GeV/c a charge-exchange cross-section of about 6 mb was found by Weinberg *et al.* [2].

At 2.8 GeV/c, in a heavy liquid bubble chamber a value of (0.20±0.25) mb was obtained by Shalamov *et al.* [3]. In 1956 Cool, Piccioni and Clark [4] have shown that this cross-section decreases above 1 GeV/c. At higher energies the only results available consist of an upper limit of 0.45 mb obtained at 16 GeV/c in a hydrogen bubble chamber by Goldsack *et al.* [5] who could not however discriminate between elastic and inelastic zero-prong events.

(A) **At 6 GeV/c,** 30 000 pictures have been scanned for zero-prong events in a fiducial volume in which an average probability of detecting the materialisation of a γ is 0.5. Among 427 events, 35 events with a pair of high energy γ-rays pointing on the π-stop have been selected for measurement. A final sample of 12 events among those for which the Q-value of the 2γ's was compatible with a π^0 mass has been submitted to a statistical treatment in order to compute the probability for each event to be a charge-exchange candidate. For this computation the measurement and scattering errors have been taken into account together with a resolution function related to the radiation loss. The procedure has been applied to all four electrons involved in each event.

Through the addition of the probabilities related to every candidate a total figure of 1.32 events was calculated. (Since none of the individual candidates exhibited a probability larger than 0.40, the search for charge-exchange events may be considered as having given a negative result.)

This number must be corrected mainly for the following effects: the average probability of observing both γ's from a π^0 was 0.23 and the scanning efficiency was 0.75.

The corrected number of candidates obtained was compared to the total number of " hydrogen-like " interactions in the same fiducial volume and related to the absorption cross-section in hydrogen. This gave us the upper limit for the elastic charge-exchange cross-section in hydrogen:

$$\sigma_{\text{ch. ex}} < 56 \mu\text{b, with } 90\% \text{ Confidence Level}$$

(B) **At 18 GeV/c,** 16,060 pictures have been scanned and 47 zero-prong events have been found. The weighted number of candidates is 0.1. After correcting this value as indicated above, an upper limit for $\sigma_{\text{ch. ex}}$ is found:

$$\sigma_{\text{ch. ex}} < 95\ \mu\text{b, with } 90\% \text{ Confidence Level}$$

2. CROSS-SECTION FOR $V^0 V^0$ PRODUCTION IN ZERO-PRONG INTERACTIONS AT 6 GeV/c

At 6 GeV/c among the 427 zero-prong events, the numbers of events for which 0, 1, 2...n γ's could be associated with 0, 1, or 2 $V^0 s$ have been recorded. From these numbers, the following ratio for strange particle production over total inelastic zero-prong interactions could be calculated.

$$\frac{N(V^0 V^0)}{\text{Total 0-prong}} = 0.33 \pm 0.07$$

The corresponding cross-section in hydrogen is found:

$$\sigma(\text{strange particles, 0-prong}) = (0.62 \pm 0.12) \text{ mb}$$

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