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L.P.C.H.E.

CEN - Saclay

Proposal for an experiment at the P.S.

STUDY OF $\pi^- p \rightarrow \pi^\circ n$ CHARGE EXCHANGE

IN FORWARD DIRECTION AT HIGH ENERGY

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25 mars 1963

Proposal for an experiment at the P.S.

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P. FALK-VAIRANT et P. SONDEREGGER

I. INTRODUCTION

Although the relativistic Regge pole theory seems to encounter now both theoretical and experimental difficulties, it has had striking confirmations in high energy p - p scattering. Current investigations bear mostly on the behaviour of the vacuum (POMERANČUK) pole. They show that at available energies the contributions of a few other conjectured Regge poles cannot be neglected.

It seems therefore of considerable interest to look for direct evidence of Regge poles other than the vacuum pole.

We propose an experiment concerning a study of $\pi^- p \longrightarrow \pi^\circ n$ charge exchange at small angles including zero degrees, with the aim of obtaining information on the ρ trajectory in the framework of relativistic Regge pole theory.

According to this theory, high energy π-p charge exchange in forward direction is dominated by Regge poles whose quantum number are those of the crossed channel : T = 1, G = +1 (Fig.1). The only candidate known at present is the trajectory belonging to the ρ meson (signature -). If this trajectory is dominant for negative t values, then the predicted asymptotic form of the cross section is

$$(1) \qquad \frac{d\sigma}{dt}(s,t) = F(t)\left(\frac{s}{s_0}\right)^{2\alpha_\rho(t)-2} \left\{\frac{1-e^{i\pi\alpha_\rho(t)}}{\sin \pi\alpha_\rho(t)}\right\}^2$$

F(t) is an unknown function related to the residue, s_o is an essentially arbitrary parameter, $\alpha_\rho(t)$ is the ρ trajectory. A measurement of $\frac{d\sigma}{dt}(t)$ at two different Lab. energies E_1 . E_2 determines then $\alpha_\rho(t)$ with a precision of

$$(2) \qquad \Delta\alpha_\rho(t) \cong \frac{1}{2\ln\frac{E_2}{E_1}}\sqrt{\left(\frac{\Delta\frac{d\sigma}{dt}(t,E_1)}{\frac{d\sigma}{dt}(t,E_1)}\right)^2 + \left(\frac{\Delta\frac{d\sigma}{dt}(t,E_2)}{\frac{d\sigma}{dt}(t,E_2)}\right)^2}$$

At present there are very few experimental results concerning high energy $\pi^- p \rightarrow \pi^o n$ charge exchange (see Table I, lines 8, 9, 10 ; we apologize for any omissions we may have made).

From $\pi^\pm$ - p total cross sections a value of $\alpha_\rho(0)$ between 0.3 and 0.5 has been deduced [1 , 2] . DRELL [3] remarks that the data are in fact compatible with $\alpha_\rho(0)$ = 1 (no Regge type behaviour). Fig.2 shows the present knowledge of the ρ

trajectory along with the CHEW-FRAUTSCHI conjecture.

The experimental technique is described in section II. Both decay photons of forward emitted π^{o}'s are detected by means of a thick spark chamber ($\sim$8 radiation lengths) triggered by an electronic system which selects elastic charge exchange events

We propose two series of measurements :

A) Low energy :

Measurement of $\frac{d\sigma}{dt}$ between $t = 0$ and $t \sim -10\mu^2$ at ten energies between 2 and 4 GeV. Desired number of events : 1000 per energy.

This energy range includes the resonances recently discovered by DIDDENS et al. [4] . The purpose is to study the transition from the region of "resonances" to the "asymptotic" region.

B) High energy :

Measurement of $\frac{d\sigma}{dt}$ at three energies around 5, 10 and 17 Gev between $t = 0$ and $t \approx -40\mu^2 = -0.8(\text{Gev/c})^2$. Required number of events : 5000 per energy, of which about 200 are at $t = -25\mu^2$ (between $-22,5$ and $-27,5\ \mu^2$). Those measurements should allow one to establish the possible shrinking of the forward peak and to determine $\alpha_\rho(t)$ with a precision of $\Delta\alpha_\rho \leqslant \pm 0.1$ between $t = 0$ and $-25\mu^2$.

II. EXPERIMENTAL TECHNIQUE

The experimental method is schematically shown in Fig.3 [1]. The liquid hydrogen target is surrounded by a set of lead converters and counters (A_1 A_2 A_3) which are in anticoincidence with the telescope (S_1 C_1 C_2 S_2 ...) defining the incident π^- beam. The spark chamber is about 8 radiation lengths thick and consists of 4 thin plates and 23 6mm brass plates of dimensions 50x50 cm. The chamber is triggered only when there are no outgoing charged particles. Furthermore, a careful geometrical arrangement of the lead converters strongly inhibits triggering for neutral events when one or more γ's are emitted outside the solid angle subtended by the chamber.

The $\pi^- p \rightarrow \pi^o n$ event is then defined by observation on a spark chamber picture of two and only two photon chowers The direction of the incident π^- is assumed to be given by the target center and the unscattered beam image in the spark chamber. The directions of both photons are given by the origins of the showers and by the target center.

The knowledge of the π^o energy and of the directions of its two decay photons yields in general two possible directions of emission of the π^o. As a first approximation, the π^o direction is assumed

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1) A similar device has been used in Saclay for an analogous experiment between 0.8 and 1.9 Gev ; a short account with preliminary results at 1.9 Gev is given in the Appendix.

to be given by the bisector between both γ's. For our geometry this ambiguity is then mainly responsible for the angular resolution which is of the order

$$\Delta \theta_{\pi^\circ}^{Lab.} \approx \pm 0.5 \frac{m_{\pi^\circ}}{p_{\pi^\circ}^{Lab.}} .$$

giving an uncertainty in the squared momentum transfer

$$\Delta t \approx \pm m_\pi \sqrt{|t|}$$

Contamination by inelastic events is expected to be small because of the selective power of the triggering system . An estimate of the number of such events can be determined by comparing the observed distribution of opening angles between the γ's with the kinematical prediction.

The distance between target and spark chamber will vary between 2 m and 6 m, depending on the beam momentum.
The liquid hydrogen target will be 30 cm long for energies up to 5 Gev, and 60 cm for energies above 5 Gev.
For the high energy measurements the chamber will occupy two azimuthal positions :

a) centered on the beam axis, for observation of events in the momentum transfer range $0 \geqslant t \geqslant -10\mu^2$. In this position the unscattered beam goes through the chamber and its intensity should not exceed $\sim$ 5000 π^- per 100 msec burst ;

b) placed at 35 cm from the beam axis it allows the observation of events in the range $-7\mu^2 > t > -40\mu^2$. (see also Fig.4). In this position the beam does not hit the chamber and a beam intensity about ten times higher can be accepted.

III. CROSS SECTION ESTIMATES.

Table I gives cross section estimatesin the framework of Regge pole theory, for beam momenta between 2 and 17 Gev/c, along with experimental results known to us.

Line 2 gives the difference $\sigma_- - \sigma_+$ between measured $\pi^- p$ and $\pi^+ p$ total cross sections [2, 4]. Knowing $\sigma_- - \sigma_+$, and assuming charge independence and unitarity one calculates the imaginary part Im T(0) of the forward charge exchange amplitude, and thereby a minimum value $\frac{d\sigma}{dt}(0)_{opt.}$ (for Re T = 0) for the forward charge exchange cross section ; this value is given on line 3.

The Regge pole hypothesis predictsthe phase which is independent of energy in the one pole approximation :

$$\left| \frac{\mathrm{Re}\ T(0)}{\mathrm{Im}\ T(0)} \right| = \left| \frac{1-\cos\pi\alpha_\rho(0)}{\sin\pi\alpha_\rho(0)} \right|$$

TABLE I : $\pi^- p \rightarrow \pi^\circ n$ CROSS SECTION ESTIMATES AND EXPERIMENTAL RESULTS.

1. Beam momentum	2 Gev/c	5 Gev/c	10 Gev/c	17 Gev/c
2. $\sigma_- - \sigma_+$	6.5 ± 0.6 mb a)	2.4 ± 0.4 a)b)	1.6 ± 0.4 b)	1.1 ± 0.3 mb b)
3. $\frac{d\sigma}{dt}(0)_{opt.} = \frac{1}{32\pi}(\sigma_- - \sigma_+)$ *	21 ± 4 $\frac{\mu b}{\mu^2}$	2.85 ± 1 $\frac{\mu b}{\mu^2}$	1.27 ± 0.7 $\frac{\mu b}{\mu^2}$	0.6 ± 0.4 $\frac{\mu b}{\mu^2}$
4. $1 + \frac{\mathrm{Re}\, T^2(0)}{\mathrm{Im}\, T^2(0)}$	? (resonance region)	$1.5^{+0.5}_{-0.25}$	$1.5^{+0.5}_{-0.25}$	$1.5^{+0.5}_{-0.25}$
5. $\frac{d\sigma}{dt}(0)$	> 20 $\frac{\mu b}{\mu^2}$	4.3 ± 2 $\frac{\mu b}{\mu^2}$	1.9 ± 1 $\frac{\mu b}{\mu^2}$	0.9 ± 0.6 $\frac{\mu b}{\mu^2}$
6. t_o (width of peak)	?	~ - 7 μ^2	~ - 7 μ^2	~ - 6 μ^2
7. $\sigma_{ch.ex.} = \int_0^{-50\mu^2} \frac{d\sigma}{dt}(0)\, e^{-\frac{t}{t_o}} dt$		~ 30 μb	~ 13 μb	~ 5.5 μb
Experimental results :				
8. $\frac{d\sigma}{dt}(0)$	~ 49 $\frac{\mu b}{\mu^2}$ c)			
9. t_o	~ - 9 μ^2 c)	- 1 μ^2 d)		
10. $\sigma_{ch.ex.} = \int_0^{\lvert t \rvert_{Max}} \frac{d\sigma}{dt}(t)\, dt$		110^{+80}_{-45} μb d) <56 μb e)	<130 μb f)	< 95 μb g)

a) DIDDENS et al. ref. [4]
b) VON DARDEL et al. ref. [2]
c) **Saclay (see appendix)**
d) FAISSNER ref. [5] : 4 Gev/c
e) BELLINI et al. ref.[6]: 6 and 18 Gev/c
f) MORRISON et al. ref. [7]:10Gev/c

* Unit of squared momentum transfer t : $\mu^2 = \mu^2 c^2 = (0.14\ \mathrm{Gev/c})^2 = 0.02\ (\mathrm{Gev/c})^2$

Line 4 gives the phase factor $\left(1 + \frac{\mathrm{Re}\,T(0)^2}{\mathrm{Im}\,T(0)^2}\right)$, for $\alpha_\rho(0) = 0.4 \pm 0.1$. The zero momentum transfer cross sections are then listed on line 5 :

$$\frac{d\sigma}{dt}(0) = \left(1 + \frac{\mathrm{Re}\,T(0)^2}{\mathrm{Im}\,T(0)^2}\right) \frac{d\sigma}{dt}(0)_{opt.}$$

The theory does not predict the variation of $\frac{d\sigma}{dt}(t)$ for $t < 0$. The uncertainty is in the choice of s_o and $F(t)$ in formula (1). One often takes $F(t) \approx$ const. and $s_o = 2M^2$ or $2\mu M$. The phase factor in formula (1) varies slowly.

For our machine time estimates we shall assume an exponential behaviour

$$\frac{d\sigma}{dt}(t) = \frac{d\sigma}{dt}(0)\, e^{-\frac{t}{t_o}}$$

with $t_o = 7\mu^2$ or $6\mu^2$ (line 6 in table I). This is the same momentum transfer dependence as observed for $p\,p \to p\,p$ and $\pi^- p \to \pi^- p$ up to $t = -50\mu^2$.

Line 7 gives the corresponding integrated cross section over the forward peak :

$$\sigma_{ch.\,ex.} = \int_0^{-50\mu^2} \frac{d\sigma}{dt}(0)\, e^{-\frac{t}{t_o}}\, dt$$

On lines 8, 9 and 10 existing experimental data are shown.

IV. NUMBER OF EVENTS.

For the cross sections given in table I and geometries and target lengths described in section II, the number of photographed events per incident pion has been calculated. In what follows we list this and other relevant figures:

A) Between 2 and 4 Gev/c.

	Spark chamber on beam axis :
Momentum transfers measured :	$0 \leqslant \lvert t \rvert < 5$ to $10\ \mu^2$
Number of events per incident pion	$\sim 2\ 10^{-4}$
Number of events per picture taken	~ 0.3
Beam intensity	5000 π^- per burst
Number of energies	10
Number of events required per energy	1000

B) At 5,10 and 17 Gev/c

		Position of spark chamber a) on axis	b) off axis
Momentum transfers measured		$0 \leqslant \lvert t \rvert < 10\ \mu^2$	$7\ \mu^2 < \lvert t \rvert \lesssim 40\ \mu^2$
Number of events per incident pion :	at 5 and 10 Gev/c	$2.5\ 10^{-5}$	$\sim 2\ 10^{-6}$
	at 17 Gev/c	$1\ 10^{-5}$	$\sim 0.5\ 10^{-6}$
Number of event per picture		0.3 to 0.1	?
Beam intensity		5000/burst	50 000/burst
Number of events required per energy		2500	3000

For the points at 5 and 10 Gev, Fig.4 shows for both azimuthal spark chamber positions :

1) The efficiency $\varepsilon(t)$ for detection of both decay photons of a π^0 emitted with squared momentum transfer $-t$.

2) The assumed cross section variation :

$$\frac{d\sigma}{dt}(t) \Big/ \frac{d\sigma}{dt}(0) = e^{-\frac{t}{t_0}}$$

3) The number of events $\frac{dN}{dt}(t)$ expected per unit interval Δt, and per incident pion. It is given by

$$\frac{1}{N_\pi} \frac{dN}{dt}(t) = n_p \frac{d\sigma}{dt}(0)\, e^{-\frac{t}{t_0}}$$

n_p is the number of target protons per cm^2.

t_o has been assumed to be $-7\,\mu^2$.

N_π is the number of incident pions.

V. BEAMS AND MACHINE TIME.

The machine time estimates are based on the information contained in sections III and IV and on the following beam properties :

A) <u>Low energy π^- beam (2 to 4 Gev)</u> :

intensity 5 000 π^- /burst

pulse duration 100 msec

$\frac{\Delta p}{p} \simeq \pm 2$ %

beam cross section at image $\leq$ 9 cm^2

angular divergence $\leq$ 10 mrad

B) <u>High energy π^- beam (5, 10, 17 Gev)</u> :

intensity	50 000 π /burst
pulse duration	100 msec
beam profile at	$\leq 9\ cm^2$
$\frac{\Delta p}{p}$	$\leq \pm 4\ \%$
angular divergence	$<$ 10 mrad

Under those conditions the required machine time is estimated to be 20 shifts for the low energy part (A) and 80 shifts for the high energy part (B) of the experiment, the time for setting up and testing not included.

This machine time is approximate and will strongly depend on preliminary results at high energy.

VI. ACKNOWLEDGMENTS.

We thank Drs. F.T. HADJIOANNOU and M. JACOB for illuminating discussions .

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L.P.C.H.E.
C.E.N. Saclay

June 6, 1963

A D D E N D U M

to : Proposal for an experiment at the P.S.
STUDY OF $\pi^- p \rightarrow \pi^0 n$ CHARGE EXCHANGE IN FORWARD DIRECTION AT HIGH ENERGY
(March 25, 1963)

I. MACHINE TIME AND BEAM INTENSITY

Discussions with Drs. HYAMS and HARTING have shown that in our original proposal the assumptions about Duty cycle of the P.S. were too pessimistic.

The original proposal needs therefore a slight modification for the high energy part (B), resulting in less machine time and less beam intensity requirements.

It should be possible to send 20'000 pions (rather than 5'000 as previous by assumed) per 100 msec burst through the spark chamber without serious analysis complication - i.e. no more than 10 to 20 % of the pictures containing a random beam track. The spark chamber position "off axis" is then no more paying and all the pictures will be taken with the spark chamber on the beam axis. The modified geometries, efficiency and number of events expected are given in Table I.

TABLE I

GEOMETRIES AND EXPECTED NUMBER OF EVENTS

1. Beam Momentum	5 Gev/c	10 Gev/c	17 Gev/c
2. Target length (liquid H_2)	15 cm	30 cm	60 cm
3. Distance Target-Spark Chamber	125 cm	250 cm	400 cm
4. Number of events per pion and per μb	0,5 10^{-6} events/μb.π^-	10^{-6} events/μb.π^-	2.10^{-6} events/μb.π^-
5. Conjectured Cross sections (see Proposal, pages 6 to 8)	30 μb	13 μb	5,5 μb
6. Number of events per burst (20'000 π^-) (for cross sections of line 5)	0,35 events/burst	0,3 events/burst	0,25 events/burst

The experiment needs therefore :

- a negative pion beam yielding 20'000 π^- per burst at 5,10 and 17 Gev/c, with $\frac{\Delta p}{p} \leqslant \pm 2\,\%$.
- 10 to 15 shifts per energy in order to get good statistics - where good statistics means : a total of $\sim$ 10'000 events, out of which $\sim$200 events with momentum transfer $22\ \mu^2 \leqslant |t| \leqslant 27\ \mu^2$. The total is about 40 shifts for three energies. This figure includes target empty measurements, and a "security factor" of 2.

II. OTHER MODIFICATIONS

The 50 cm x 50 cm spark chamber will be made 12 radiation lengths thick. 10 Gev γ rays can then be stopped in the chamber, and a very rough determination of the relative energies of both decay photons should be feasible by comparing the number of sparks in both showers.

Two small spark chambers will define the direction of the incident pion.

Both modifications should help to improve the angular resolution.

III. SUMMARY OF RELEVANT DATA

For comparison with other experimental approaches, we summarize relevant data for the experimental technique proposed. The device is that described in our original proposal, with the modifications listed above.

Detection efficiency : The overall detection efficiency is high for momentum transfers up to 40 μ^2 :

90 % for a π^0 emitted at 0°

70 % for a π^0 emitted at $t = - 25\ \mu^2$.

It is felt that good statistics are essential for the experiment proposed. The high detection efficiency seems therefore to be a major advantage of the proposed device.

Angular resolution : The angular resolution has been calculated and is

$$\Delta t_{r.m.s.} = \pm 0{,}6\ \mu_\pi \sqrt{-t} \begin{cases} \approx 0 \text{ in forward direction} \\ = \pm 3\ \mu_\pi^2 \text{ at } t = -25\ \mu_\pi^2 \end{cases}$$

at all energies, or

$$\Delta\theta_{r.m.s.} = \pm 4 \text{ m rad at } 10 \text{ Gev/c (all } t).$$

Complexity of Data Analysis :

Analysis is simple. The principle is outlined on pages 4 and 5 of the Proposal. The data processing of the similar experiment done at Saclay shows that there is no major difficulty once the anticoincidence counters are elaborate enough to detect large angle photons with good efficiency.

Scanning and measuring equipment as well as computer programs exist and are working.

September 10th, 1963

A D D E N D U M II

THE CONTAMINATION BY INELASTIC EVENTS

We have calculated in detail the expected contributions of two photon pictures from the most dangerous reactions :

$$\pi^- p \longrightarrow \pi^0 \pi^0 n$$

and $$\pi^- p \longrightarrow \omega n \qquad (\omega \longrightarrow \pi^0 \gamma)$$

The calculations were done by Monte Carlo Technique, taking into account the geometry of the experiment and the energy dependant γ ray efficiency of the counters.

Two models were used for the calculation : the convariant statistical model and a peripheral model sharply peaked in forward direction, of the Chew-Low-Selleri type.

For both reactions the probability of mistaking a $\pi^0 \pi^0 n$ or ωn event for a charge exchange event is of the order of 0.5 % for the peripheral model (and three times smaller for the statistical model).

These contributions are measurable as the corresponding distributions of opening angles between the 2 photons differ strongly from the one for elastic charge exchange π^0's .

Discrimination against inelastic events is an order of magnitude better than it was in the similar Saclay experiment, mainly for the following three reasons :

- the anticoincidence counters around the target will be lead-scintillator sandwiches;
- the counters will contain more lead converter;
- the geometry will be such that all γ's will hit either the spark chamber or the lead counters.

APPENDIX

PRELIMINARY ACCOUNT OF A STUDY OF $\pi^- p \rightarrow \pi^0 n$ CHARGE EXCHANGE IN FORWARD DIRECTION BETWEEN 0.9 AND 2 Gev/c

A. Description of the experiment.

This work has been done at the Proton Synchrotron SATURNE by P. BORGEAUD, S. BREHIN, Y. DUCROS, P. FALK-VAIRANT, O. GUISAN, J. MOVCHET, P. SONDEREGGER, A. STIRLING, M.YVERT and S.D.WARSHAW.

The main purpose was to test a zero momentum transfer dispersion relation.

The experimental technique was similar to that described in Section II (see also Fig.4). The liquid hydrogen target was 15 cm long, the distance between target and spark chamber was 90 cm.

90 000 pictures were taken at 13 beam momenta between 0.9 and 2 Gev/c.A total of 10 000 $\pi^- p \longrightarrow \pi^0 n$ events were obtained, between 500 and 1000 at each momentum. The ratio of good events to pictures taken varied between 1/10 at 1 Gev/c and 1/3 at 2 Gev/c. The beam intensity was about 2000 π^- per

100 msec burst.

Fig. 5 shows a typical event. The average number of sparks per gap was 4 to 6 at a depth of 3 to 4 radiation lengths.

Analysis of pictures is in progress.

B. Preliminary results at 2 Gev/c.

We report preliminary results based on 464 events out of 750 events photographed at 1.85 Gev incident pion kinetic energy. The events are required to have opening angles between the two decay photons between 7° (kinematical limit) and 29°. 6 events which do not satisfy this criterion are probably inelastic. Fig. 6 shows the angular distribution of the remaining 458 events. The analysis yields for each observed event two possible angles of π° emission ; both are assumed to equally probable. Each event is then weighted by its calculated inverse probability, given by the probability that both decay photons enter the spark chamber (Monte Carlo calculation) and materialize inside the fiducial volume.

The angular distribution of the weighted events is fitted by an exponential (Fig.6). This fit is bad at large angles and is used mainly for extrapolation to 0°. We obtain an uncorrected cross section

$$\frac{d\sigma}{dt}(t) = \frac{d\sigma}{dt}(0) \; e^{-\frac{t}{t_0}} \quad \text{with}$$

$$\frac{d\sigma}{dt}(t)_{\text{non corr.}} = 52 \pm 5.5 \; \mu b / \mu_\pi^2$$

$$t_0 \approx -9 \, \mu_\pi^2$$

In order to test wether the observed π^0's are from elastic charge exchange or wether there is a background from other events, we analyse the distribution of the opening angles between the decay photons. This distribution is rather sensitive to the π^0 spectrum.

Fig. 7 shows the distribution of opening angles φ for all events, including 6 events with $\varphi < 7°$ or $\varphi > 29°$. The events are weighted by the inverse probability for materialization inside the fiducial volume. We have compared this distribution with the theoretical distribution which is determined by a Monte Carlo calculation, assuming that all observed events are $\pi^- p \longrightarrow \pi^0 n$ ("elastic"). The shape of the peak around the minimum opening angle ($\sim 8°$) depends strongly on the average beam momentum. The best fit is obtained by assuming a beam momentum of 1.96 Gev/c which is compatible with hot wire measurements.

Both distributions are normalized to the same area between 7° and 29°.

Fig.8 shows the observed opening angle distribution after subtraction of the calculated distribution. There is an excess of events left outside the peak region ($\sim 8°$) which is attributed to an inelastic background from processes like

$$\pi^- p \longrightarrow \pi^0 \pi^0 n$$

or

$$\pi^- p \longrightarrow \pi^0 \gamma n$$

In the region around 30° there are four events which are probably

$$\pi^- p \longrightarrow \underset{\downarrow \atop 2\gamma}{\eta} + n$$

The background of inelastic events with $7° < \varphi < 29°$ is found to be 5 % $\pm$ 2 %.

The presence of this background is mainly explained by the fact that there was a solid angle of about 0.14 sr which was not seen by the lead converters nor by the spark chamber. In the experiment proposed here the geometry of lead converters (see Fig.4) will be such that every photon emitted from the target will convert either in the spark chamber or give an anticoincidence signal ; the anticoincidence efficiency increase with energy.

After subtraction of the inelastic background and after correction for target empty effect (5 %) μ contamination (2 %) and beam attenuation, in the target (1 %), we get a corrected value of the cross section in forward direction

$$\frac{d\sigma}{dt}(0)_{corr} = 48.5 \pm 6 \, \mu b/\mu^2 \quad \text{or} \quad \frac{d\sigma}{d\Omega}(0°) = 3.12 \pm 0.40 \, mb/sr$$

This figure is compatible with the dispersion relation prediction, which we recalculated taking into account new high energy total cross section data [2, 4] :

$$\frac{d\sigma}{d\Omega}(0°)_{D.R.} \simeq 2.9 \pm 0.4 \, mb/sr$$

Saclay 1.4.1963

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[2] VON DARDEL et al. Phys.Rev.Letters 8, 173 (1962)

[3] DRELL, CERN Proceedings 1962, p. 908

[4] DIDDENS et al. Preprint 1963

[5] FAISSNER (preliminary, quoted by DRELL, CERN Proceedings 1962 page 908)

[6] BELLINI et al., CERN Proceedings 1962, p.586

[7] MORRISON et al. (quoted by COCCONI, CERN Proceedings 1962 page 888).

FIG. 1 : $\pi^- p \to \pi^\circ n$ Charge Exchange
Direct and crossed channel.

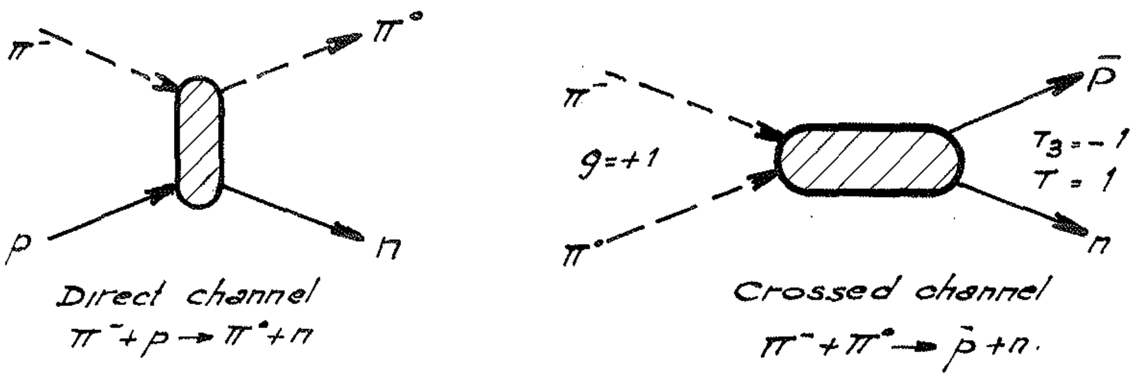
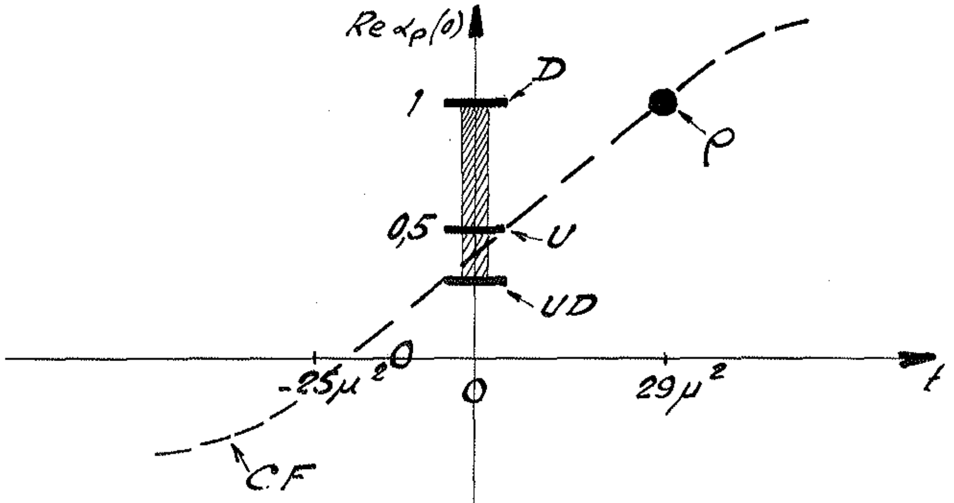


FIG. 2 : Present knowledge of ρ trajectory

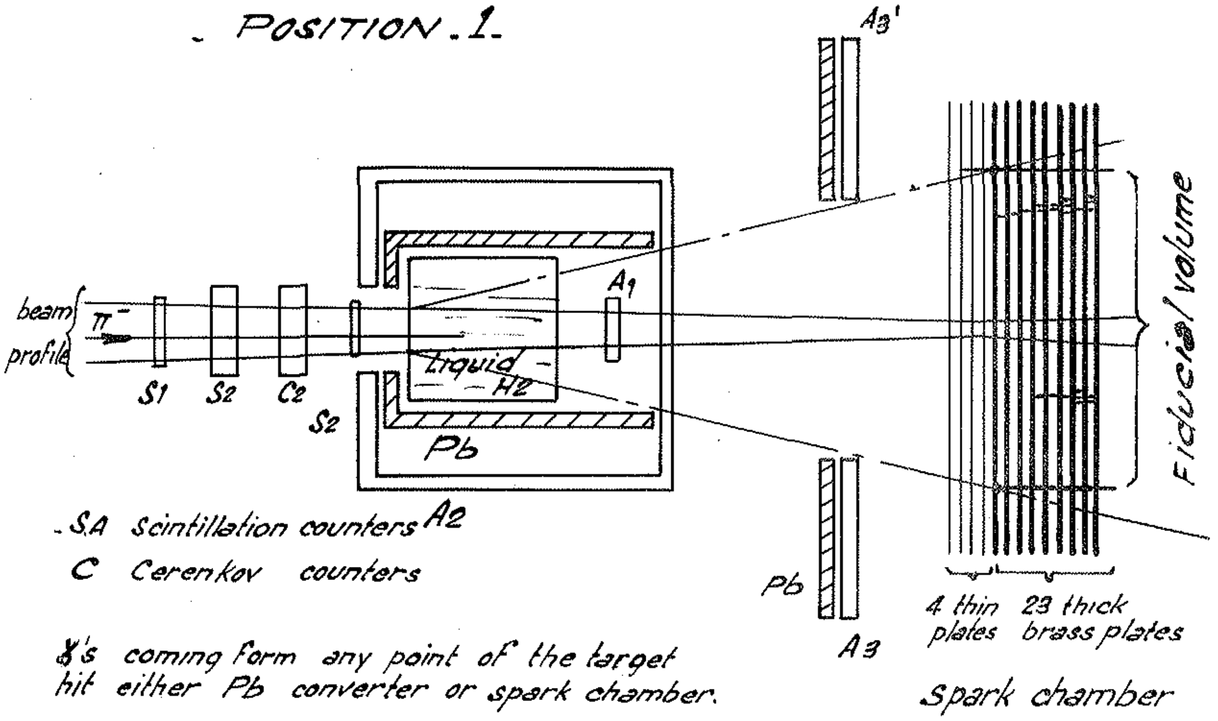


CF : Trajectory conjectured following Chew and Frautschi
$t = 29\mu^2$: Physical ρ meson

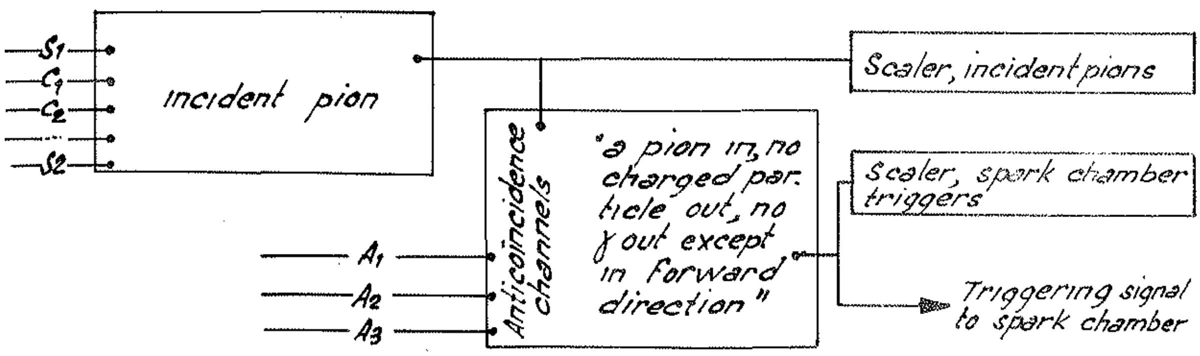
$t = 0$
- UD : Von Dardel et al. ref. [2]
- U : B. Udgaonkar ref [1]
- D : the value $\alpha_\rho(0) = 1$ cannot be excluded. Drell, ref. [3]

FIG. 3 - EXPERIMENTAL LAYOUT
(schematical, not to scale)

- POSITION - 1 -



ELECTRONICS (schematical block diagram)



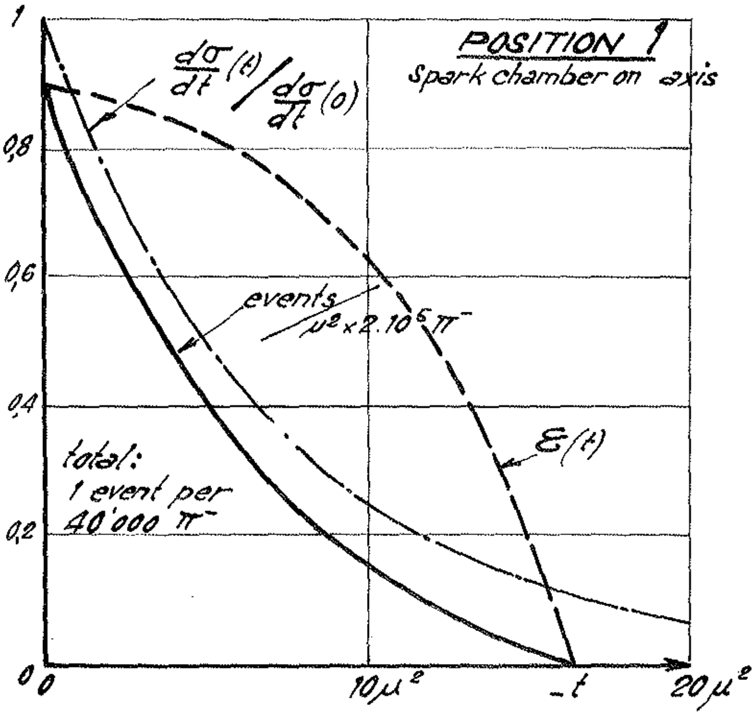


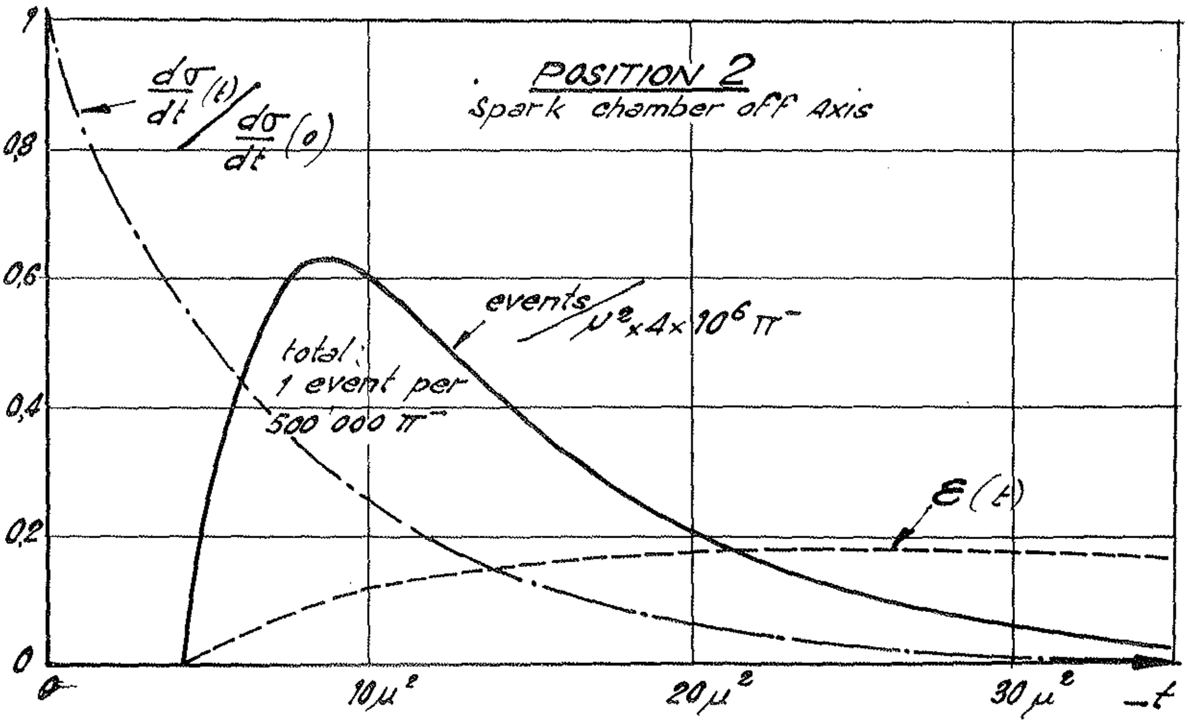
FIG. 4

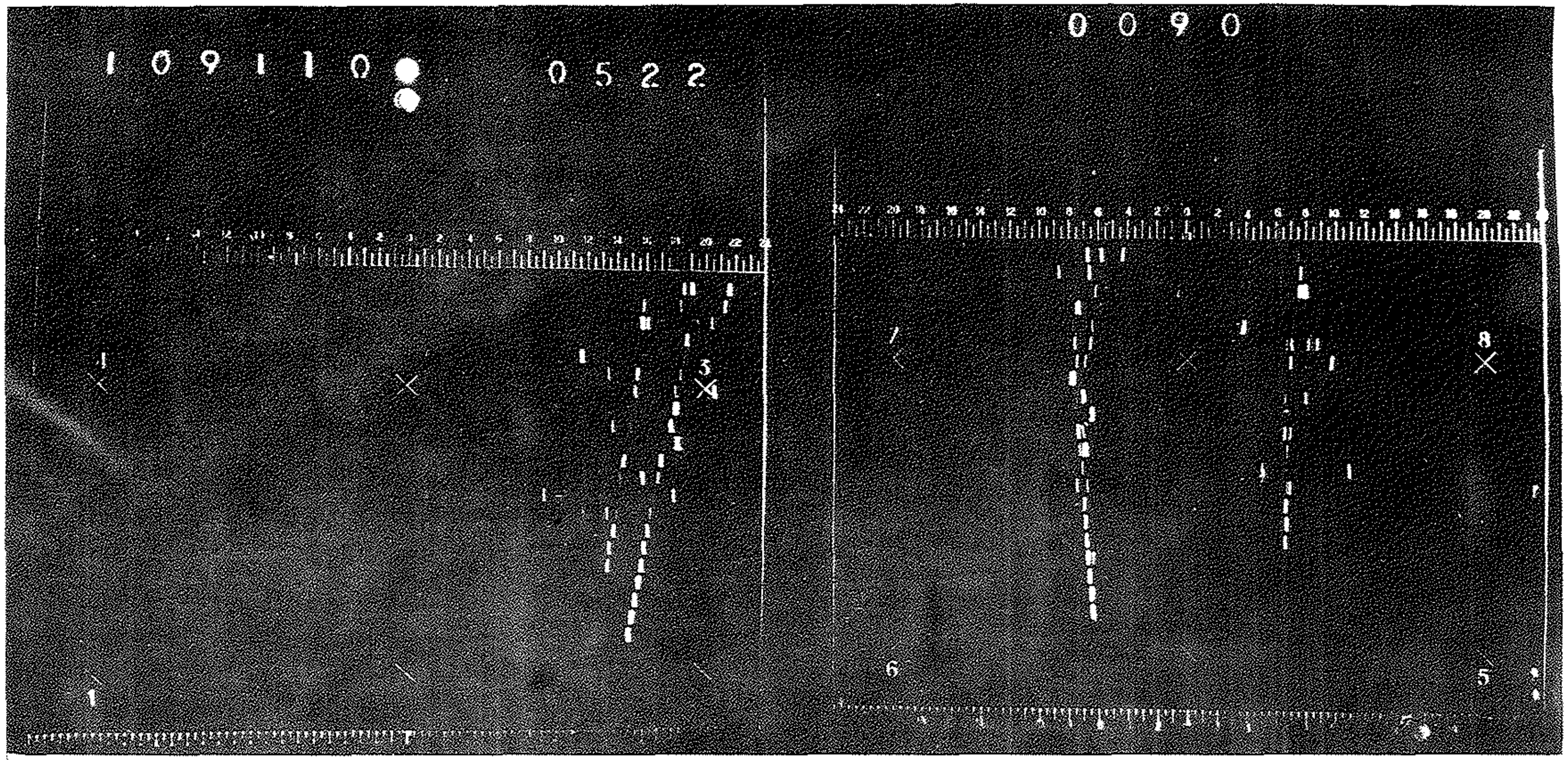
π° detection efficiency $\varepsilon(t)$ and expected number of events per incident pion and per momentum transfer interval.

Figures hold for 5 and 10 gev/c

Assumed cross section

$$\frac{d\sigma}{dt}(t) \Big/ \frac{d\sigma}{dt}(0) = e^{-\frac{|t|}{4\mu^2}}$$





View 1 γ_2 γ_1 View 2 γ_1 γ_2

FIG. 5 : TYPICAL $\pi^\circ n$ EVENT OBTAINED AT 2 GeV/c AT SACLAY

Two views at 90° stereo

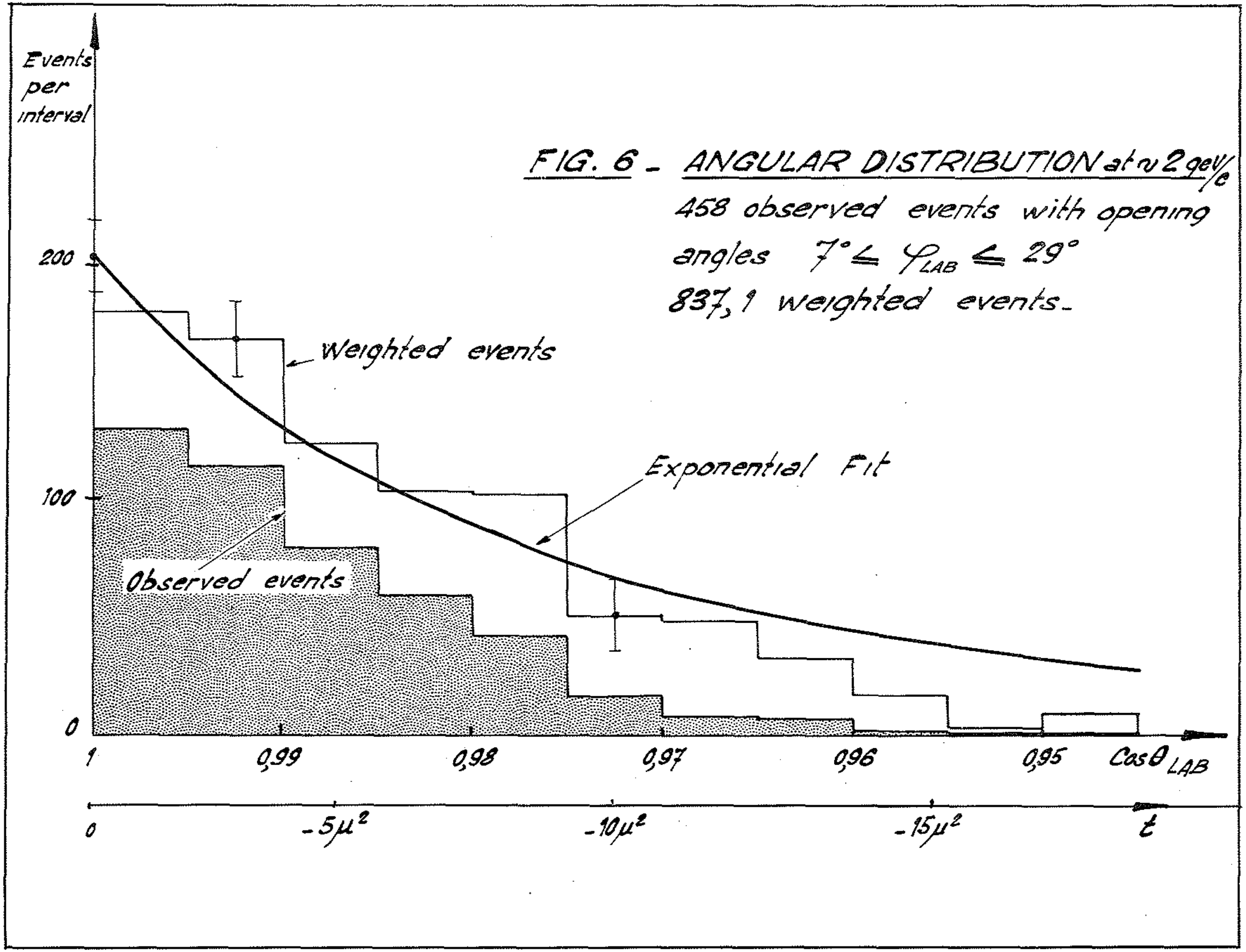


FIG. 6 - ANGULAR DISTRIBUTION at ~ 2 gev/c
458 observed events with opening angles $7° \leq \varphi_{LAB} \leq 29°$
837,1 weighted events.

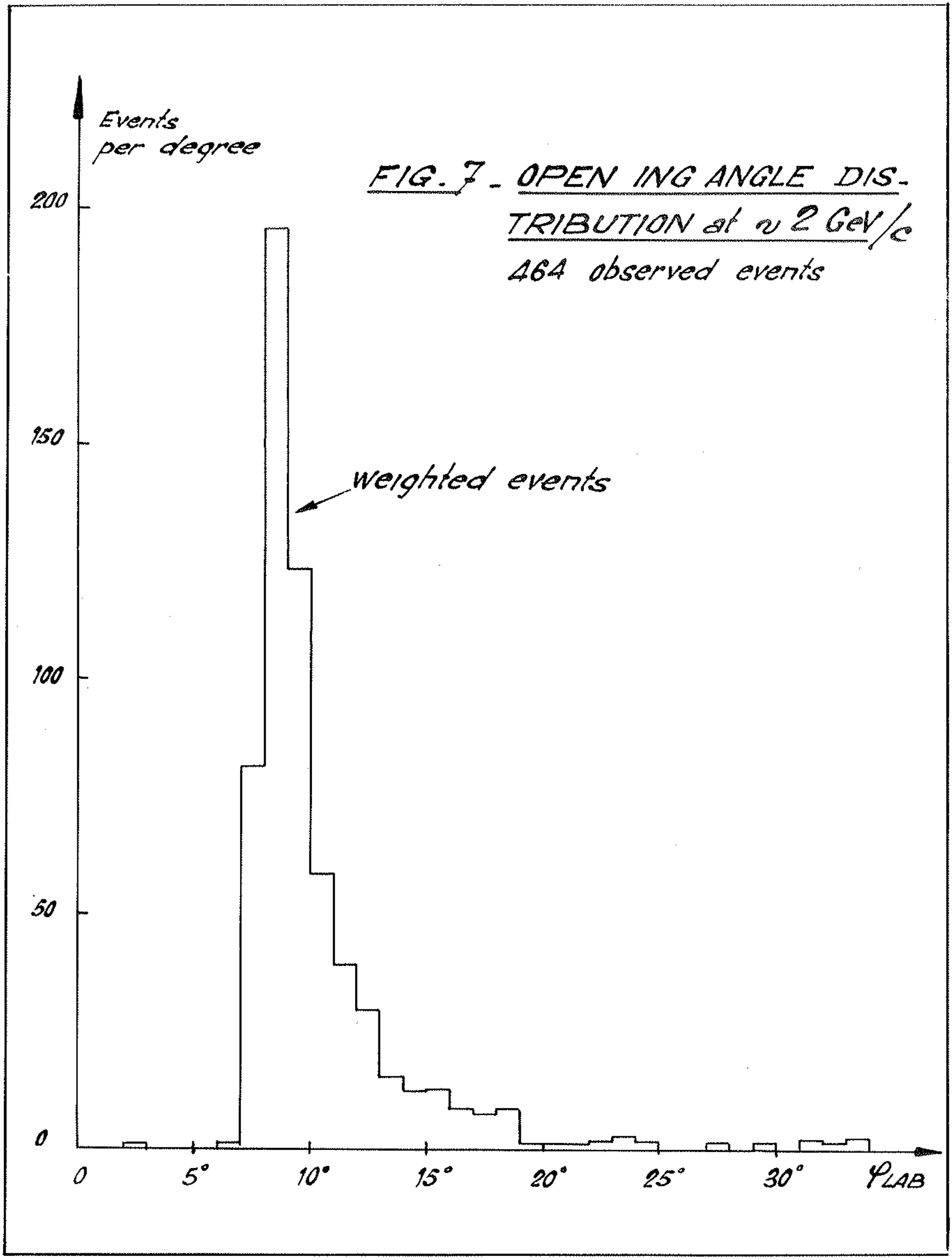


FIG. 7 - OPEN ING ANGLE DISTRIBUTION at ~ 2 GeV/c
464 observed events
Events per degree
200
150
100
50
0
weighted events
0
5°
10°
15°
20°
25°
30°
φLAB

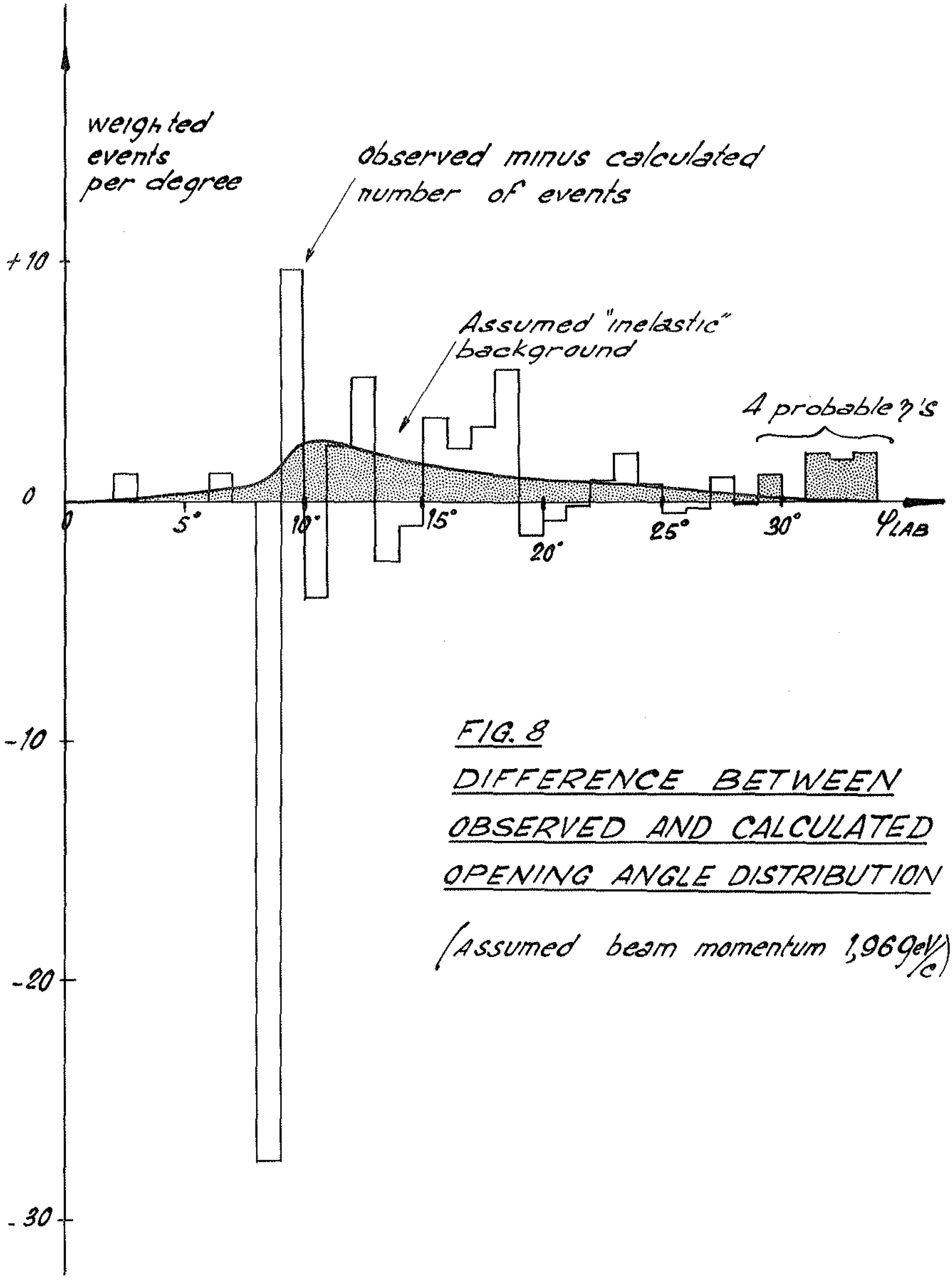


FIG. 8

DIFFERENCE BETWEEN OBSERVED AND CALCULATED OPENING ANGLE DISTRIBUTION

(Assumed beam momentum 1,96 GeV/c)