ЛАБОРАТОРИЯ ЯДЕРНЫХ ПРОБЛЕМ

ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

Yu.D. Prokoshkin, V.I. Rykalin,
I.M. Vasilevski

D –678

SEARCH FOR THRESHOLD ANOMALIES IN THE ENERGY DEPENDENCE OF THE TOTAL CROSS SECTION FOR PROTON-PROTON INTERACTION

ЖЭТФ, 1961, т40, в5, с1524-1525

Дубна 1961

Yu.D. Prokoshkin, V.I. Rykalin,
I.M. Vasilevski

D -678

SEARCH FOR THRESHOLD ANOMALIES IN THE ENERGY DEPENDENCE OF THE TOTAL CROSS SECTION FOR PROTON-PROTON INTERACTION

As has been shown by Wigner and Baz'[1], the energy dependence of the cross section for elastic scattering of two particles may have an anomalous character in the vicinity of the threshold for the production of a new particle. These anomalies appear as a narrow 'casp' or a'rounded step' and are due to a sharp change in the derivative of the cross section at the threshold point. The threshold anomalies may take place also in the energy dependence of the total cross section for two particle interaction[1].

We make an attempt to find these anomalies in the vicinities of the thresholds for pair production of pions in proton-proton collisions (580-600 MeV). The investigations of the energy dependence of the total cross section for proton-proton interaction σ were also performed in the regions lying above and below the thresholds. The discovery of the anomalies in the latter cases could serve as an indication to the existence of new particles[3] and allow to determine their mass.

To record the protons a differential ionization chamber has been used. This permitted to accomplish the high accuracy in determining the relative behaviour of the energy dependence of the cross section which exceeds by an order the accuracy characteristic of the experiments performed earlier where in the measurements of the magnitude σ the counters of particles were applied[4].

An experimental arrangement is given in Fig. 1. An external proton beam from the six-meter phasotron of the Joint Institute for Nuclear Research was formed by a system of collimators and passed through three identical thin-walled ionization chambers. The first chamber served as a monitor. The second and the third ones between which a polyethelene target was placed were a differential ionization chamber. The current of this differential chamber i_2 was proportional to the magnitude of the attenuation of the beam when it is traversing the target, i.e., to the total cross section multiplied by the intensity of the beam J . The current i_2 was amplified and recorded on the record chart of the self-recording potentiometer.

When the thickness of the absorber slowing down the proton beam increased gradually the curve was drawn on the chart record showing how the magnitude $i_2 \sim \sigma J$ changes with the decreasing proton energy E . At the same time another potentiometer recorded the change of the current of the chamber-monitor $i_1 \sim J$. The dependence $\sigma(E)$ has been found by dividing i_2 by i_1 . This was accomplished by means of a permanently operating electronic computer whose output signal proportional to i_2/i_1 was recorded along the record chart of the third potentiometer. The measurements were repeated many times to exclude the influence of small fluctuations of the differential chamber current.

1/ Details see in review[2].

The energy of the beam was determined with an accuracy higher than 1 MeV /5/. The energy resolution comprised ± 5 MeV and was determined by the dispersion of the beam /5/ (± 3 MeV) and by the energy losses in the target (± 4 MeV).

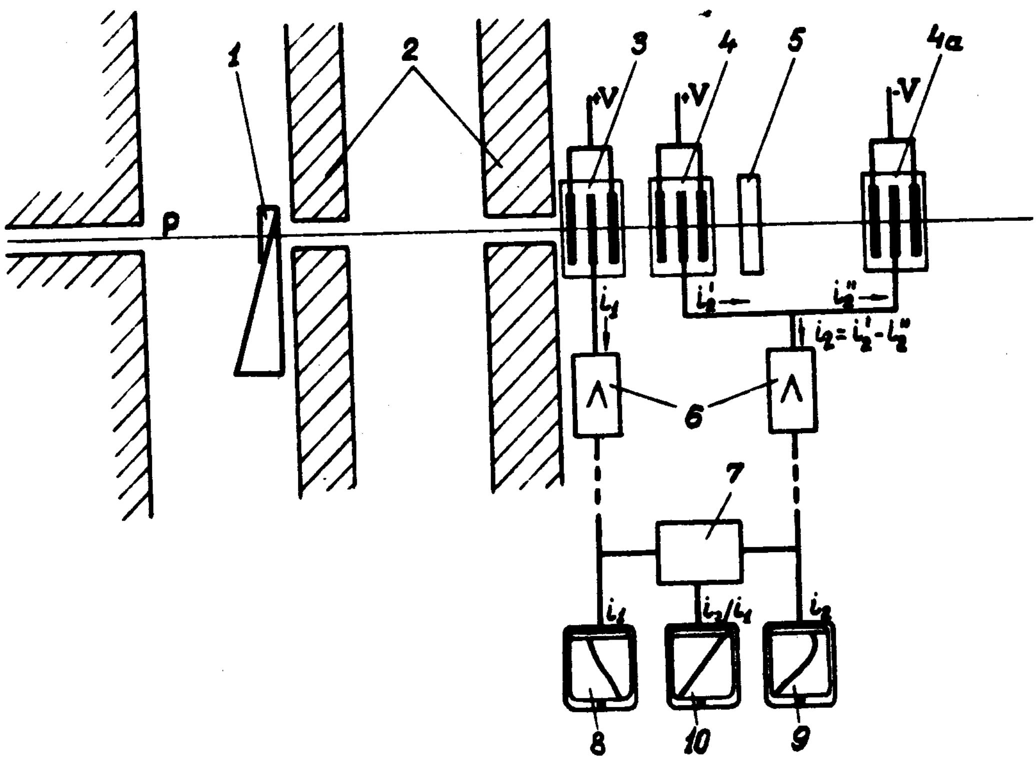

Fig. 1.

The lay-out of the apparatus (in arbitrary scale). **P** *is a proton beam;* **1** *is a wedge-shaped absorber for proton slowing down;* **2** *are shielding walls;* **3** *is an ionization chamber-monitor;* **4** *and* **4a** *is an ionization differential chamber;* **5** *is a target;* **6** *are amplifiers;* **7** *is an electronic computer dividing* i_2 *by* i_1 *;* **8** *and* **9** *are self-recording potentiometers registering the currents* i_1 *and* i_2 *;* **10** *is a potentiometer registering the quotient* i_2/i_1

The results of the measurements are presented in Fig. 2.

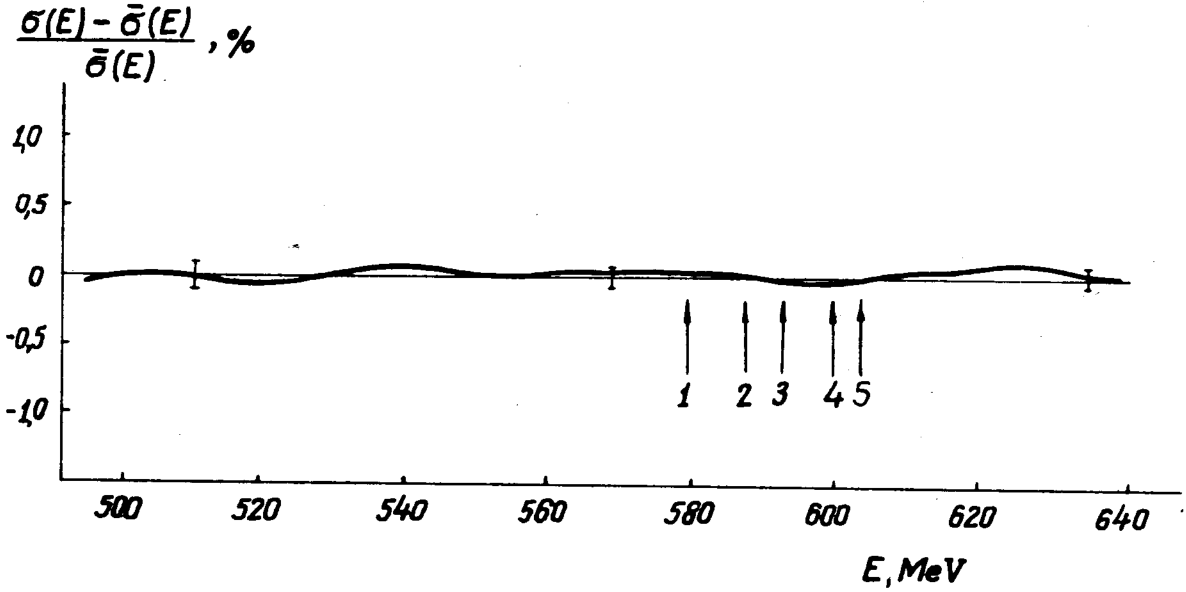

Fig. 2.

$\frac{\sigma(E)-\bar{\sigma}(E)}{\bar{\sigma}(E)}$ *versus the proton energy* **E**. **I** *are measurement errors.*

The arrows indicate the thresholds for the reactions:

$pp \to pp\pi^0\pi^0$ (1),

$pp \to d\pi^0\pi^+$ (2),

$pp \to pn\pi^0\pi^+$ (3),

$pp \to pp\pi^+\pi^-$ (4),

$pp \to nn\pi^+\pi^+$ (5).

Here is plotted the magnitude of the relative deviation of the measured cross section $\sigma(E)$ from the curve of the energy dependence averaged over wide energy range $\bar{\sigma}(E)$ which is linear in this energy region/4/. As is seen from Fig.2 there are no anomalies in the energy dependence of the total cross section for **P – P** interaction which would exceed the error in the measurements (0.1%). Hence, it follows that the existence of the bound system ' π meson + nucleon ' with the binding energy close to zero is unlikely.

Simultaneously, control experiments were made in which the graphite target was used. The energy dependence of the total cross section for carbon must not contain appreciable anomalies due to the nucleon motion in the carbon nucleus. In accord with this, the measurements made have shown that the deviation of the magnitude $\sigma(E)$ from $\bar{\sigma}(E)$ does not exceed 0.05% for carbon.

In conclusion the authors take the opportunity of thanking A.I. Baz', L.I. Lapidus and B.Pontecorvo for the discussion of the present paper.

References

1. E. Wigner. Phys.Rev., 73, 1002, 1948; А.И.Базь.ЖЭТФ. 33, 923,1957.
2. L. Fonda. Inelastic collisions and threshold effects, preprint 1960.
   Здесь же приведена литература.
3. В.Г. Зинов, А.Д. Конин, С.М. Коренченко, Б. Понтекорво. ЖЭТФ, 36, 1948, 1959; В.И. Гольданский, Я.А. Смородинский. ЖЭТФ, 36, 1950, 1959.
4. В.П. Джелепов, В.И. Москалев, С.В. Медведь. ДАН СССР, 104,380 1955.
   F. Chen, C. Leavitt, A. Shapiro. Phys.Rev., 103, 211, 1956.
5. И.М. Василевский, Ю.Д. Прокошкин. Атомная энергия, 7, 225, 1959.

Received by Publishing Department on February 10, 1961.