Study of Anomalous Pion Production in Proton-Nucleus Collisions

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Several recent measurements of proton induced pion production on medium mass target nuclei revealed a considerable increase of pion yields at about 350 MeV proton energy with a relatively narrow width of about 5 MeV[1,2]. This resonance-like structure could be accounted for by a new phenomena in connection with non-nucleon degrees of freedom in nuclei. Normal nuclear excitations would be extremely broad at such a high excitation energy. Since the more definite justification of the resonance-like structure comes from low energy (below 70MeV) pion production, it was proposed by A.Kurepin and K.Oganesyan[1,3] that the resonance could be due to the quasi-bound state of two $\Delta(1232)$ isobars in nuclear matter, and predominantly decayed in the two pion channel. Then the maximum pion energy is $T_p(\sim 350\text{MeV}) - 2 \times m_{\pi^+} \simeq 70\text{MeV}$.

There are still discussions on the experimental results[4]. In order to confirm the structure experimentally, we performed precise measurements of excitation functions for positive pion production in proton-nucleus collisions. The LAS spectrometer was used to analyze pion momentum. After rejection of backgrounds by dE-dE and time-of-flight mesurements by two scintillators, the position at focal plane was determined by two VDCs. The pion production cross section and the analyzing power on a Cu target were measured at several proton energies from 344 to 356 Mev in step of about 1 MeV at a pion production angle of 90 degrees. To change the beam energy in a small step, carbon absorbars were placed at the first focus point after the Ring Cyclotron. Beam energies on target were calibrated with p+C scatterings by the Grand Raiden. The uncertainty in the energy determination was less than 0.1 MeV.

Full energy spectrum of double differential pion production cross sections were measured at each energies. The exitation function of the integrated cross section and ratios of cross sections for high-energy (75∼100MeV) and low-energy (30∼60MeV) pion production were fitted with a sum of a quadratic polynomial plus a Breit-Wigner term

$$A + BE + CE^2 + \frac{D}{(E - E_0)^2 + \Gamma} .$$

From the preliminary analysis we found a small enhancement in the ratio of cross sections at $E_0 = 351.8\text{MeV}$ with a width of about $\Gamma = 5.5\text{MeV}$. Figure 1 shows the double differential cross section of 356MeV, and results of the preliminary analysis is shown in Fig. 2.

References

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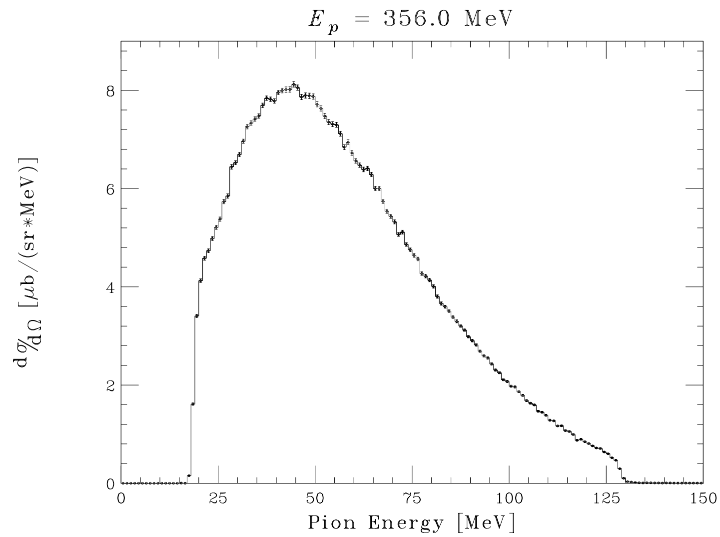

Figure 1: Double differential π^+ production cross section versus pion kinetic energy.

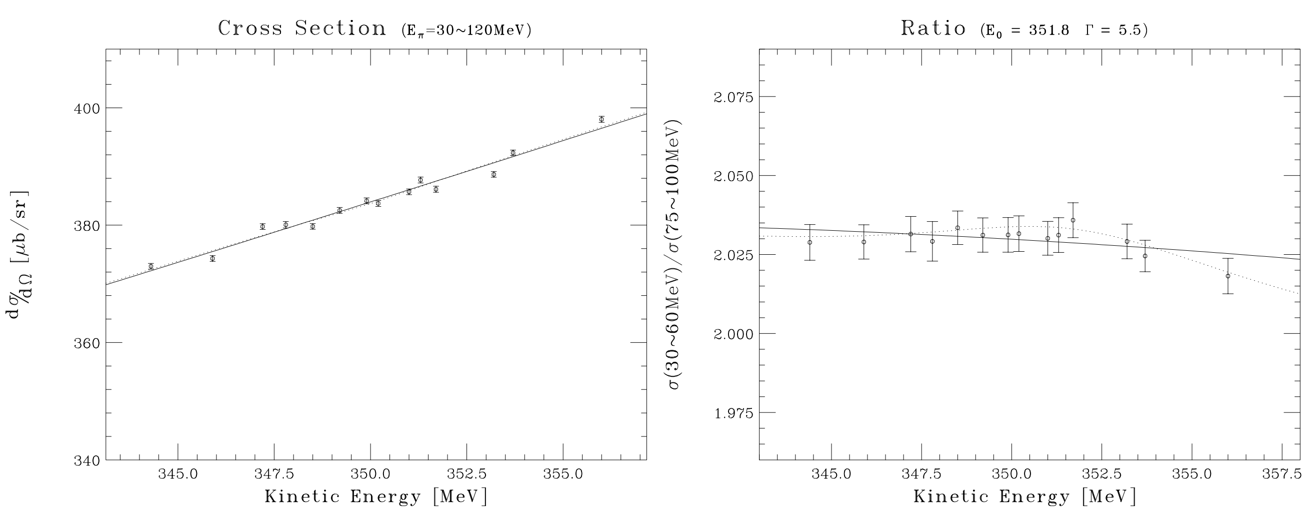

Figure 2: Bombarding energy dependence of the pion production . Solid and dotted lines are obtained by a least-square fit with a quadratic polynome and a Breit-Wigner term.