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**DOUBLE PION PHOTOPRODUCTION USING THE DAPHNE DETECTOR:  
PRELIMINARY RESULTS**

## DOUBLE PION PHOTOPRODUCTION USING THE DAPHNE DETECTOR: PRELIMINARY RESULTS

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### Abstract

Preliminary results on the reaction  $\gamma(p, p\pi^+\pi^-)$ , obtained using DAPHNE detector in conjunction with the Mainz MAMI-B tagged photon beam, are shown. Already from a reduced data set, we are able to obtain a much higher precision with respect to the previous experiments.

## 1. DAPHNE Set-up

DAPHNE (Detecteur à large Acceptance pour la PHysique Nucleaire Experimentale) is a large acceptance hadron detector which has been developed by the I.N.F.N., sezione di Pavia and the DAPNIA/SEPN of Saclay in order to perform a variety of intermediate energy photonuclear experiments on few body systems. This device consists of a tracking detector, including 3 coaxial cylindrical multiwire proportional chambers, surrounded by a segmented cylindrical scintillator telescope for charged particle identification and finally a scintillator-absorber sandwich, designed to enhance the detection efficiency for  $\pi^0$ 's (for a detailed description, see ref. [1]).

The plan view and section of the detector are shown in figure 1.

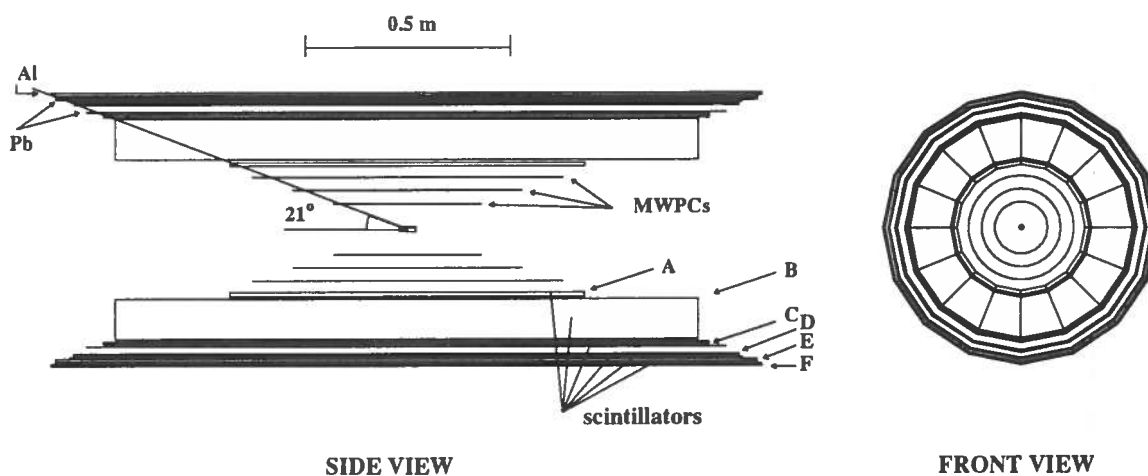


Fig. 1

It follows from the cylindrical symmetry of the design that the coverage of the azimuthal angle is complete. The angular range in the polar direction is  $21^\circ - 159^\circ$ , corresponding to 94% of  $4\pi$ .

The experimental apparatus includes also a cryogenic target that can be filled with liquid hydrogen, deuterium,  $^3\text{He}$  and  $^4\text{He}$ .

DAPHNE is associated with the tagged photon facility installed at the new continuous wave facility MAMI-B in Mainz [2].

This accelerator provides electrons up to 855 MeV.

Photons are obtained by bremsstrahlung of the primary beam through a very thin radiator ( $\simeq 10^{-4}$  radiation lengths).

The detection of the associated electron in the tagging spectrometer not only determines the energy of the outgoing photon but also allows a reliable evaluation of the photon flux.

In its present configuration the Glasgow-Edinburgh-Mainz tagger [3], covers the photon energy range of  $50 \leq E_\gamma \leq 800$  MeV with a resolution of about 2 MeV.

This performance is obtained by using a 352 channels hodoscope, each channel supporting a maximum intensity of about  $1 \cdot 10^6$  electrons per second.

## 2. The experimental program

The first part of DAPHNE experimental program includes:

- i) The extension of  $\sigma_{tot}$  measurements to the lightest nuclei ( ${}^3He, {}^4He$ ). These results will help to understand what happens to baryon resonances of higher energy than the  $\Delta$ .

It is known from earlier experiments that while these resonances are well evident on  ${}^1H$  and  ${}^2H$ , they are strongly damped on the nuclei having  $A \geq 9$  (see, for instance, [4] and references therein).

The behaviour of this phenomenon for the nuclei having  $3 \leq A \leq 9$  will contribute in the understanding of the excitation mechanisms inside the nuclear medium of these resonances.

- ii) The study of  $\gamma + {}^3He \rightarrow ppn$  reaction that will give indications on the photoabsorption mechanisms. In particular our  $4\pi$  detector is well suited to show processes involving all 3 nucleons.
- iii) Pion photoproduction reactions on deuterium. Selecting kinematical conditions far from the quasi free mechanism, it will be possible to study the  $\Delta - N$

interaction.

- iv) The analysis of double pion photoproduction reactions on the nucleon to study its isobaric states as a complementary method to i).

### 3. Present state of the research program

After the setting up of the whole apparatus, the data taking started in May 1992, together with the beginning of MAMI-B activity.

The experimental data collected up to now on the different reactions come from a total of about 390 hours of beam time.

We collected roughly 60 – 70 "good" hadronic events per second (the on-line acquisition rate was  $\approx 120$  Hz).

This rate indicates that, thanks to the DAPHNE acceptance and to the tagged beam intensity, we will get a greatly improved statistics with respect to all the previous experiments in this domain.

Then, we hope to reach some interpretation of the above mentioned phenomena reasonably supported by the experimental data.

In the analysis, we have so far taken into account the double photoproduction mechanisms on the nucleon and, in particular, we have worked out mostly data concerning the reaction:  $p(\gamma, p\pi^+\pi^-)$ .

In this case it is enough to measure the directions of all outgoing particles to have a complete kinematical reconstruction of the process.

In this way, systematic errors are minimized because direct measurement of the particles energies is not needed.

If one of the final state particles is not detected by DAPHNE it is still possible to identify the reaction and when the energy of at least one of the detected particles can be determined, the reconstruction of the whole kinematics can be achieved.

A sample of about  $6 \cdot 10^5$  events concerning this reaction has been collected so far and in about half of them all 3 particles are detected.

In the following section we will present some preliminary results obtained with a relatively small sample of  $\simeq 30.000$  events where all particles were detected. However such results give a first description of the elementary mechanisms involved in the double photoproduction processes.

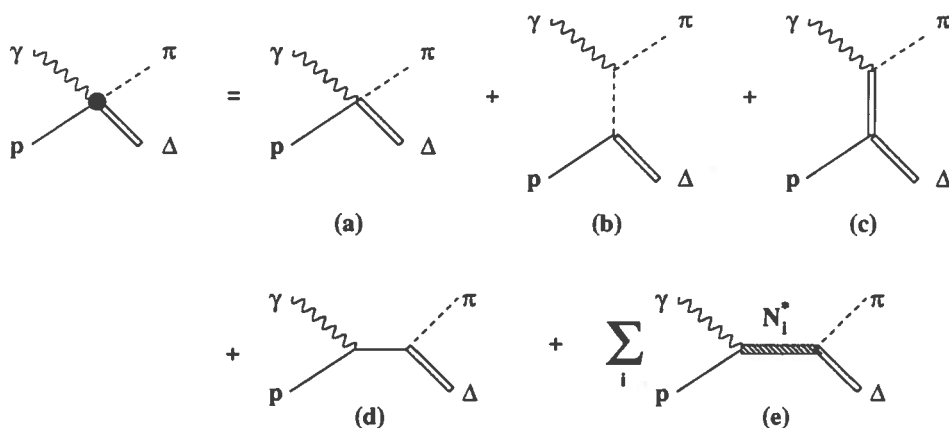
#### 4. Results

The invariant masses of the two possible  $(p\pi)$  systems, evaluated event by event, are displayed in the Dalitz plots of figure 2 for some photon energy bins.

The relative experimental error on these quantities, due to the high DAPHNE angular resolution ( $\Delta\vartheta \leq 1^\circ$  fwhm;  $\Delta\varphi \simeq 2^\circ$  fwhm) is about 1% (fwhm).

We can recognize, that the invariant masses are centered around the  $\Delta$  mass values and this feature indicates that the reaction goes through the intermediate  $\Delta\pi$  state.

This characteristic was explained by a model proposed by Lüke and Söding (ref.[5]); in the framework of the gauge invariant Born approximation, they showed that 5 elementary mechanisms contribute to the double photoproduction process:



$$\gamma + p \rightarrow p + \pi^+ + \pi^- \quad E_\gamma = 350.-790 \text{ MeV}$$

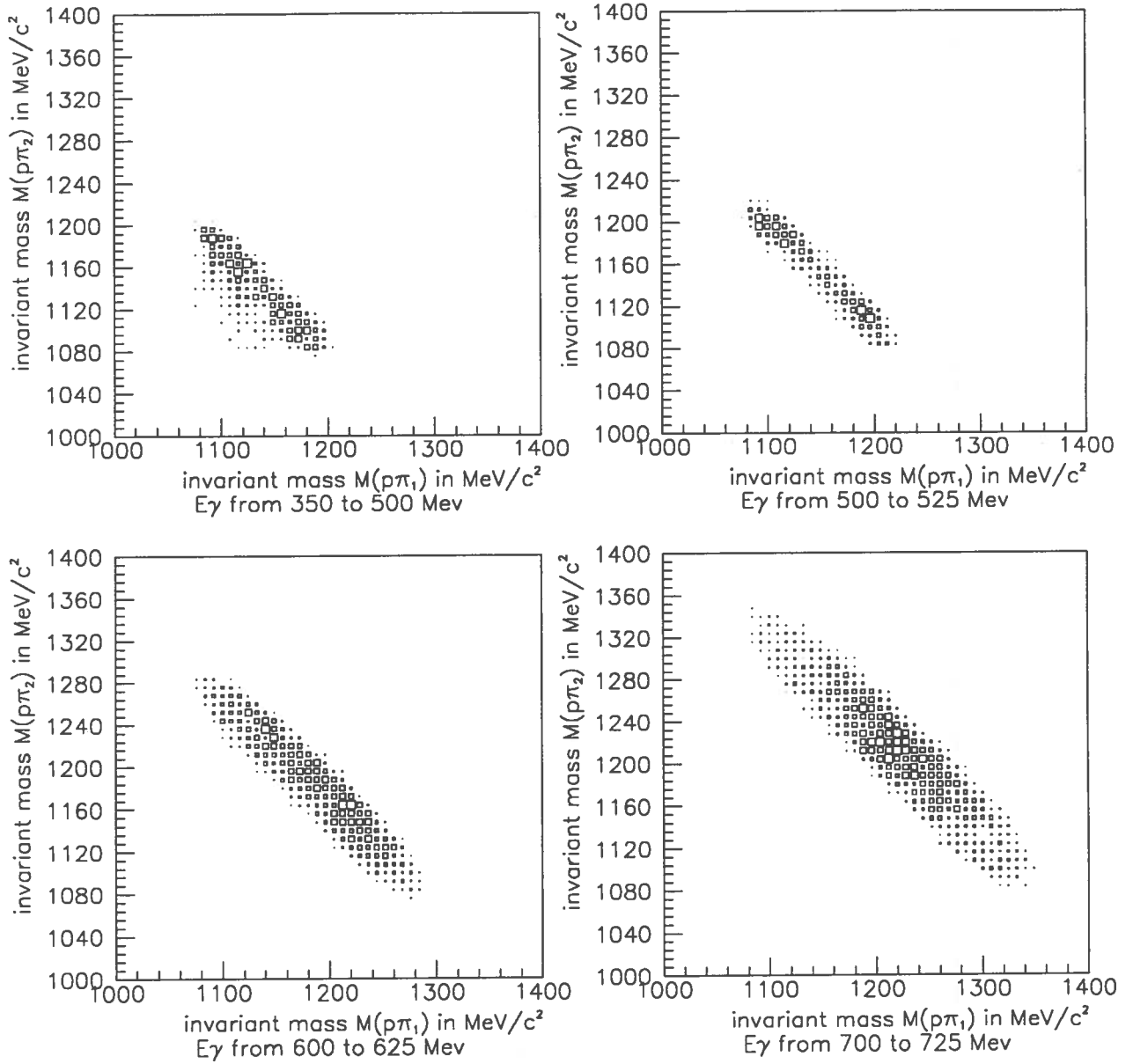


Fig. 2

Near the threshold, only diagrams (a) and (b) (the so-called contact and photoelectric terms) are important: processes (c) and (d) formally serve to ensure gauge invariance but are numerically negligible below 1 GeV.

The higher resonances decaying into a  $\Delta\pi$  state (e) should be taken into account when  $E_\gamma$  is greater than  $\approx 650$  MeV.

In figure 3 a comparison between the theoretical total cross section and the experimental values is shown.

The theoretical curve was calculated only for (a) and (b) diagrams and integrated over the acceptance of DAPHNE.

The agreement between the theoretical and the experimental curve in the region  $350 \leq E_\gamma \leq 640$  MeV allows us to use, in this energy range, the Lüke and Söding model to extrapolate DAPHNE data in order to get the absolute value of the total cross section.

The final result is shown in figure 4 where data coming from two bubble chambers measurements (ref. [6] and [7]) are also shown.

Despite the fact that our data come from a small part of the total events, we can already see a much higher precision with respect to the previous experiments.

The final analysis will allow us to calculate the cross section without model dependent extrapolations.

## 5. Conclusions

A very preliminary analysis done with a reduced set of data already offers statistically significant results on the  $p(\gamma, p\pi^+\pi^-)$  reaction.

We obtained a clear indication about the elementary mechanisms that are dominant in the double photoproduction reaction near the threshold and we could derive precise total cross section values in the region  $350 \leq E_\gamma \leq 640$  MeV.

The analysis of the whole sample of the events will allow to measure the differential and total cross section values with a precision much greater than that available up to now and, by consequence, to distinguish the different mechanisms contributing to the double pion photoproduction.



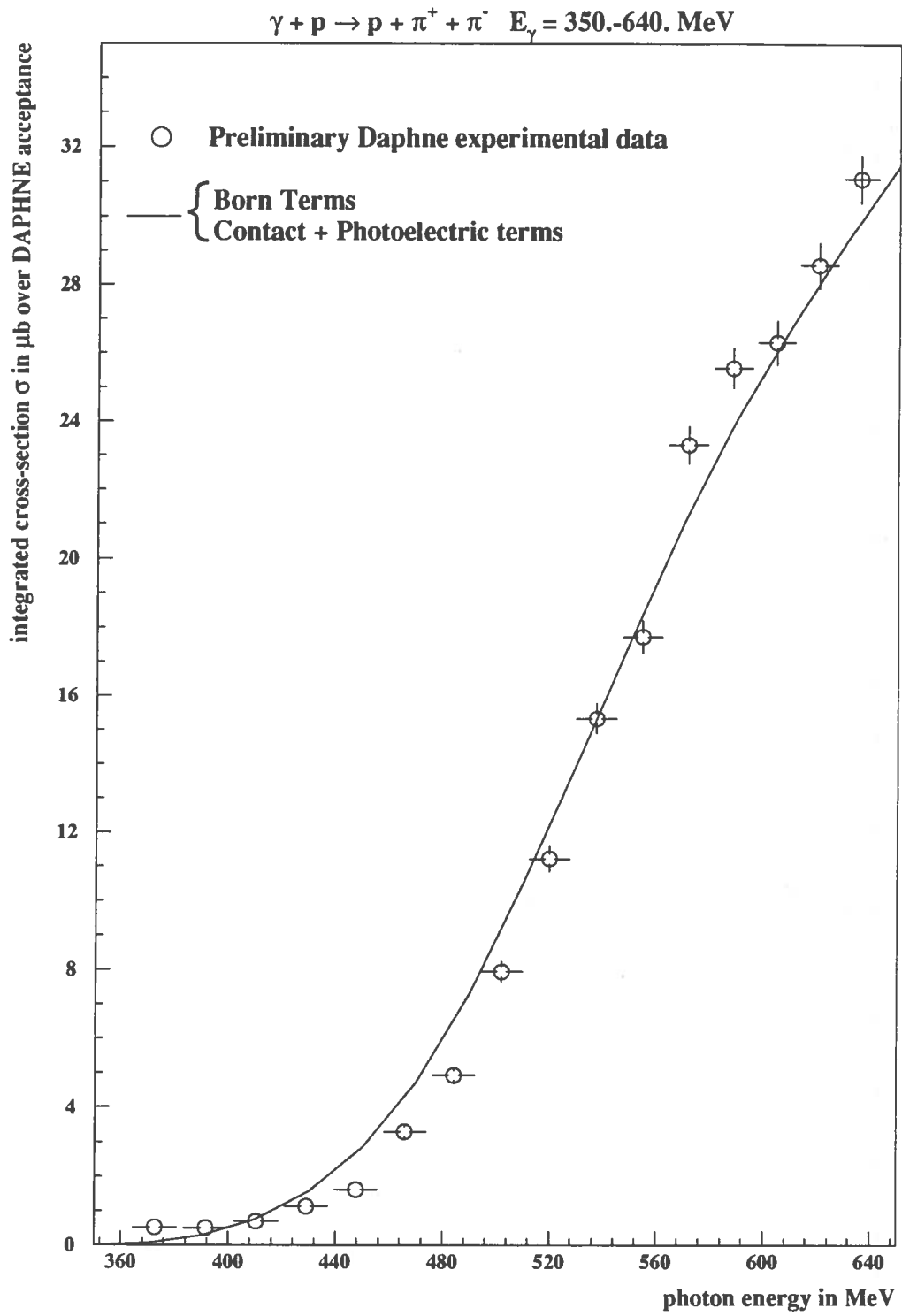


Fig. 3

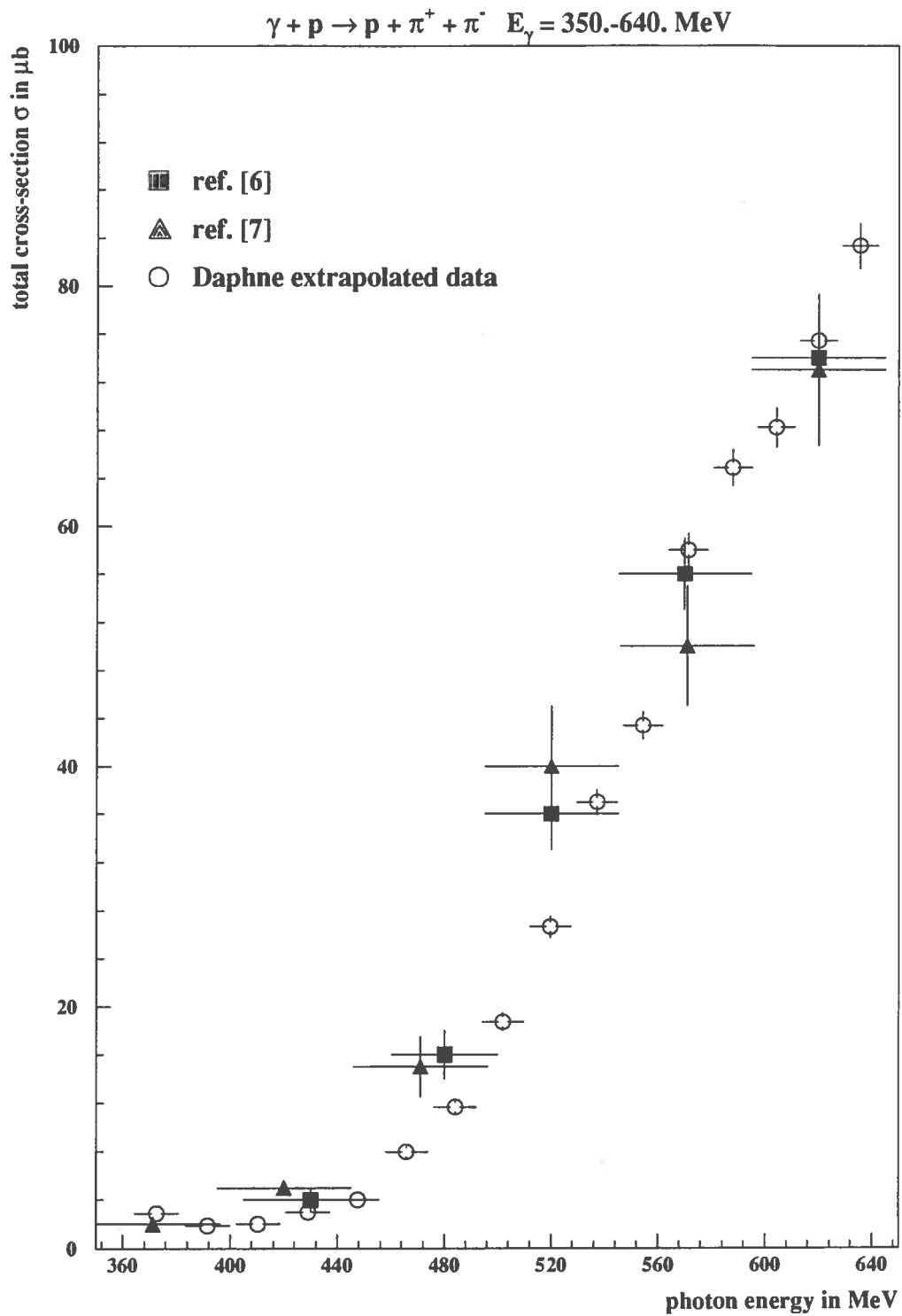


Fig. 4

## References

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