2 A Brief Historical Survey

Experiments on Compton scattering from the proton were first reported in the 1950s by Pugh et al. [1], Oxley et al. [2], Govorkov et al. [3] and Hyman et al. [4]. The photon energy range covered by these experiments extended from 30 MeV to 140 MeV. The first experimental results in the $\Delta$ resonance region were published in 1959 by Littauer et al. [5], followed by Gol’danski et al. [6], Bernardini et al. [7], DeWire et al. [8], Stiening et al. [9], Baranov et al. [10] and Gray et al. [11] in the 1960s. The photon beams were produced by electron beams from betatrons or synchrotrons hitting thin radiators and thus emitting bremsstrahlung. The principle used to detect the scattered photons was almost the same for all experiments. The scattered photons traversed a thick absorber, which reduced the electron background, followed by a telescope of plastic counters and converters. Pugh et al. used additionally a liquid scintillator to obtain information about the energy of the photon, which converted into an electron–positron pair.

At photon energies exceeding the $\pi$ threshold, the recoiling proton is able to leave the target and can be detected in addition to the scattered photon. By making use of the kinematics, such a coincidence measurement not only helps to reduce electromagnetic background, but also helps to distinguish between photon–proton events caused by Compton scattering and events caused by $\pi^0$ photoproduction. As an example of how the data of these early experiments were recorded and analyzed, the article of Bernardini et al. [7] very accurately describes the electronic equipment. The following can be found:

The three pulses were displayed on a Tektronix Model 517 A oscilloscope. A sweep with a speed of 50 ns/cm was used. It was triggered by the master coincidence output with the longer resolving time. (...)

The oscilloscope traces were photographed with a DuMont Type 314 Oscillograph Record Camera. Eastman Kodak Linagraph Ortho Film ran at a constant speed in the camera, so that the film length indicated the time elapsed between the events.

The processed films were projected on a screen from which the pulse heights and the timing of the three pulses were measured.

This example already demonstrates the very basic principle of modern data acquisition systems, except that the analog signals were transformed into digital information by the experimenters themselves. The result of this
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experiment (Fig. 2.1) shows remarkable agreement with the most modern theoretical calculation by L’vov et al. [12]. It should also be emphasized that the statistical uncertainties are rather small. It was concluded from these early experiments that the $t$-channel exchange of a neutral $\pi$ meson, proposed by Low in 1954 [4, 7, 13], is of major importance [4, 7].

Compton scattering in the $\Delta$-resonance region was continued in the 1970s by Genzel et al. [14] in Bonn. The outstanding feature of these experiments was that the energy dependence was measured over a wide angular range. For years these results were the basis of an intense discussion, because the data seemed to violate the unitarity bounds of Compton scattering. This puzzle has been solved by later experiments, discussed in this book. In 1980 Ishii et al. [15] performed some remarkable experiments which cover an energy range of 375 MeV up to 1150 MeV. Ishii et al. used a Pb-glass detector for the scattered photons and a high-resolution magnetic spectrometer to trace the recoiling protons.

The so-called “modern” experiments started in 1991 with those of Federspiel et al. [16], the first experiment which reliably determined the electromagnetic polarizabilities of the proton. All the subsequent experiments will be cited later in this book. In this brief overview, only the experiments covering an energy range up to the $\Delta$ resonance region have been considered. At higher energies, many more experiments have been performed. In Fig. 2.2, a kinematical overview of the experiments before 1990 is given. There are only a few experiments in the $\Delta$-resonance region from 200 MeV to 500 MeV. The challenge was to fill this gap, i.e. to perform experiments over a wide angular and energy range.

Today, two approaches to produce intense monoenergetic photon beams have emerged: (i) backscattering of laser light by high-energy electron beams,