beams of different energies.

10.6 Experimental determination of Q

Q of a reaction can be determined with the help of Eq. (10.5-1) by measurement of the energies E_x, E_y and E_Y accurately. It can also be estimated from the precise values of the atomic masses of the nuclei taking part in the reaction, using Eq. (10.5-2). If one of the product nuclei (Y) is a heavy particle, then it is usually difficult to measure its kinetic energy (E_Y) accurately. However, it can be determined with the help of Eq. (10.5-6) from a knowledge of the masses and by measuring the energies E_x and E_y accurately. In this case the precise values of the masses need not be used. Instead the corresponding mass numbers will suffice.

If the emitted particle y is a charged particle, then one can use a scintillation counter, a proportional counter (gas-filled). a solid state counter or a magnetic spectrograph to determine its energy.

Scintillation spectrometers can be used when the resolving power needed is not very high. Since the charged particles have very small ranges in solids, the scintillation detector to be used can be quite thin for low energy reaction studies. The scintillator can be located close to the target to increase the solid angle which helps improve the statistics of counting. The resolving power is usually low, being ~ 20 to 30.

With solid state spectrometers, the resolving power is much better, being ~ 200 to 300. Since solid state detectors with sufficiently thick active layers are available now a days, one can go upto fairly high energies.

Magnetic spectrometers are by far the most suitable instruments for high resolution work. Resolving powers of the order of 1000 have been achieved with these instruments. Both single focusing and double focussing instruments have been developed. In the former, the particles emerging from a point on the median plane are focussed along a line

perpendicular to that plane, while in the latter, a point-object produces a point-image. Double focussing can be achieved in a number of different ways. In one of these, an inhomogeneous magnetic field is used which is similar to the Svartholm-Siegbahn β-rays spectrometer (see § 5.4.).

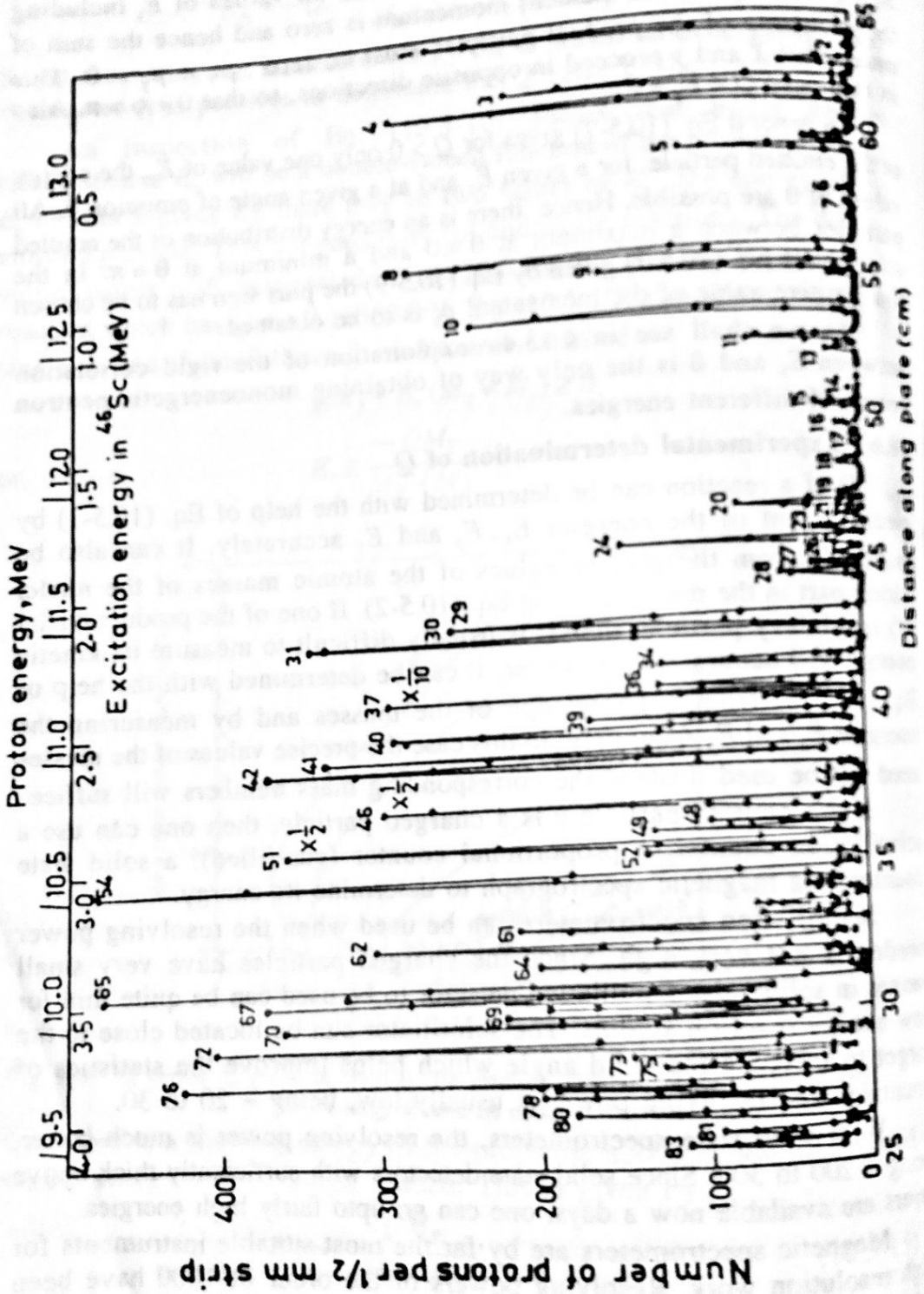

Fig. 10.7. Energy spectrum of protons from ^{45}Sc(d, p) ^{46}Sc reaction at $\theta = 37.5°$ in a multigap magnetic spectrograph (from J. Rapoport, A. Sperdut & W.W. Buechner).

A highly versatile multigap magnetic spectrograph with nuclear emulsion plates as detectors has been used by H.A. Enge, and W.W. Buechner at the Massachusetts Institute of Technology (MIT) in the U.S.A. (see *Rev. Sci. Instr.* 34, 155, 1963). This instrument is actually twenty four instruments in one large vacuum chamber. Both energy and angular distributions of the particles are recorded simultaneously. Energy distributions at different angles θ at the interval of 7.5° are obtained.

After exposure, the plates are developed and scanned under microscopes. The number of tracks of the particles having the correct length and direction are counted. At each exposure lasting for 1 – 10 hr the number of data points obtained is 36000.

Fig. 10.7 shows a typical spectrum obtained with this instrument for the reaction ^{45}Sc (d, p) ^{46}Sc using a deuteron beam accelerated in the 8 MeV Van de Graaff generator. The different peaks correspond to different states of the residual nucleus ^{46}Sc.

Differential cross sections $d\sigma/d\Omega$ for the peaks at different energies as functions of the angle of emission were also determined. These show pronounced maxima in the forward direction.

The positions of the maxima are determined by the orbital angular momenta of the states in which the neutron is captured in the (d, p) reaction.

10.7 Cockroft and Walton's experiment on nuclear transmutation