CHAPTER -IV

EXPERIMENTAL DETAILS
4. EXPERIMENTAL DETAILS:

The experiment was performed in Variable Energy Cyclotron Centre (VECC), Calcutta and consists of the following equipments.

a) Beam of alpha particles of 50 MeV energy,
b) 36 inches scattering chamber,
c) polyethelene target,
d) charged particles detection system and
e) electronics and data acquisition system.

The details of each are as following.

4.1 Beam:

The alpha particle beam of required energy was obtained from the sector focussed variable energy cyclotron (224 cm pole diameter) of Calcutta. The incident energies of alpha particles for the present experiment were 50 MeV. Beam resolution was known to be ~ 0.4%. Beam energies were determined from the elastic and in-elastic (4.439 MeV excited state) peaks of carbon in the target. The size of the beam was about 2 mm. The beam current was set between 2-3 nA to avoid burning of the target film at high current. Integrated charges were measured by using a Faraday cup.

4.2 The Scattering chamber:

The 36 inches scattering chamber [1] was used for the experiment. It was fabricated from twelve plates of Al-alloy welded together forming the bihexagonal chamber body,
possessing several access windows (10 inches dia.) together with beam entrance and exit ports and pumping port.

Two independent arms (turnable) each of which can carry five detectors separated by 10° hold the detector housing and their collimators. One can fix detectors with respect to the target in steps of 1 inch. from 4.5 inches to 15.5 inches in five radial arrays in each of the two arms (Fig. 4.1).

Five targets can be mounted at a time on a ladder. The targets can be rotated about their vertical axis (vertical axis of the ladder) and can be brought into the beam line one by one without breaking the vacuum. Positioning of targets and rotations of both targets and two arms containing detector and collimator assemblies can be accomplished by both local and remote control units, without breaking the vacuum. For beam monitoring, a Faraday cup at the exit port was used.

The vacuum system for the chamber consists of a 9 inches fractionating oil diffusion pump, a liquid nitrogen trap, an electromagnetic angle gate valve, a 500 lpm mechanical backing pump with a fore line liquid nitrogen trap. The system was coupled to the chamber body through an insulating adapter and insulator bushings.

4.3 Target:

The deuterated polyethylene foils (cd₂)n (70% isotopic purity) were used as target. The thickness of the target foil was about 720 μg/cm². Three (cd₂)n targets and one carbon (mylar) target were held on the target ladder (Fig. 4.2). Each hole of the target ladder was of 0.8 cm diameter.

4.4 Detectors:

Detectors used in the present experiment were EG&G ORTEC make Si(Li) semiconductor detectors. Using the alpha particle beam of 50 MeV energy, deuteron
Fig. 4.1. Schematic of one of the arms within the scattering chamber with 12 slots in each radial array; angular difference between any two consecutive radial arrays is 10°
Fig. 4.2. Target arrangement in the ladder
break-up events were detected by observing coincidences between a 1 mm Si(Li) semiconductor alpha detector and a two counter proton telescope consisting of a 300 μm ΔE and a 5 mm Si(Li) E detector. The alpha and proton detectors were placed in opposite side of the beam and their centres were coplanar with the beam. A 500 μm detector was used as monitor.

The energy resolutions of the detectors used were less than 100 keV and were measured using α sources of $^{239}$Pu (5.165 MeV) and $^{241}$Am (5.486 MeV). The required thicknesses of the detectors were estimated from the range energy curves (Fig. 4.3) for alpha, deuteron and proton.

4.5 Collimators:

The collimators used in front of the detectors were made of tantalum sheets. The holes in the tantalum collimators were 5 mm diameter (circular) for both alpha and proton telescope. For the monitor detector, a 4 x 2 mm$^2$ rectangular collimator was used. The tantalum sheets were thick enough to stop all the particles which hit the area surrounding the hole. The required thicknesses for the collimators were determined using the range energy data.

4.6 Solid angles:

Solid angles of the detectors were determined from the dimension of the collimator's slit and target to detector distances. Collimators were set immediately in front of the detectors. Each detector with collimator was placed in a detector housing specially made for the detector. The detector assembly thus formed was placed on a turnable arm within the scattering chamber. The monitor was kept fixed under the roof of the chamber at an angle of 15° with respect to the beam. The proton telescope and the α particle detector were placed on two different arms on the opposite side of the incident beam. The detector
Fig. 4.3. Range-energy curves for $\alpha$-particles, deuteron and proton in silicon (Ref. [2])
to target distances were 24.5 cm for the 1 mm alpha detector and 23.2 cm for the E+ΔE proton telescope. This arrangement of detectors fulfills the requirement for phase-space factor discussed in chapter III.

4.7 Electronics and data acquisition:

A block diagram of the electronics used in the experiment with beam energy of 50 MeV and the experimental layout inside the scattering chamber is shown in Fig. 4.4.

The preamplifier used to collect the signal from the alpha detector (1 mm thick) was a Tennelec made quad preamplifier and for the proton telescope 142AH ORTEC preamplifiers were used. The ORTEC 572 amplifiers were used for all the detectors. The pulses from the amplifiers were fed to timing single channel analyser (ORTEC 551 timing SCA). A slow-fast coincidence set up was used where the negative logic pulses from the TSCA's were fed to a time to amplitude converter (TAC) circuit and the positive logic pulses were fed to a coincidence unit. The TAC used was an ORTEC 567 TAC/SCA and the coincidence unit was an ORTEC 418A universal coincidence unit. The pulse from the proton detector was used as a start and that from the alpha detector was used as a stop input for the TAC. The SCA output from the TAC was used as a master pulse. The unipolar pulses from the linear amplifiers were fed to CAMAC ADC's. The list mode data were taken in ND 100 and ND 500 computers and were transferred to magtape for subsequent analysis. The spectrum of the monitor detector was observed in a Canberra 88 multichannel analyser.
Fig. 4.4: Block diagram of the experimental set up

T: Target
M: Monitor detector
E_α: Alpha particle detector
E: Proton detector
ΔE: Thin proton detector

LA: Linear Amplifier
PA: Pre Amplifier
DA: Delay Amplifier
TSCA: Timing Single Channel Analyser
TAC: Time to Amplitude Converter
MCA: Multichannel Analyser
References:


   cited in "Nucler Instruments and systems", EG & ORTEC, 86-87