energy scale measures the distance from the *K*-shell edge energy of germanium (11.104 keV). These curves are taken from Hubbell, McMaster, Del Grande & Mallett (1974). Not only does the experimental curve depart significantly from the theoretically predicted curve, but there is a marked difference in the complexity of the curves between the various germanium compounds.

Far from the absorption edge, the theoretical calculations and the experimental data are in reasonable agreement with what one might expect using the sum rule for the various scattering cross sections and one could say that this region is one in which normal attenuation coefficients may be found.

Closer to the edge, the almost periodic variation of the mass attenuation coefficient is called the extended X-ray absorption fine structure (XAFS). Very close to the edge, more complicated fluctuations occur. These are referred to as X-ray absorption near edge fine structure (XANES). The boundary of the XAFS and XANES regions is somewhat arbitrary, and the physical basis for making the distinction between the two will be outlined in Subsection 4.2.3.4.

Even in the region where normal attenuation may be thought to occur, cooperative effects can exist, which can affect both the Rayleigh and the Compton scattering contributions to the total attenuation cross section. The effect of cooperative Rayleigh scattering has been discussed by Gerward, Thuesen, Stibius-Jensen & Alstrup (1979), Gerward (1981, 1982, 1983), Creagh & Hubbell (1987), and Creagh (1987*a*). That the Compton scattering contribution depends on the physical state of the scattering medium has been discussed by Cooper (1985).

Care must therefore be taken to consider the physical state of the system under investigation when estimates of the theoretical interaction cross sections are made.

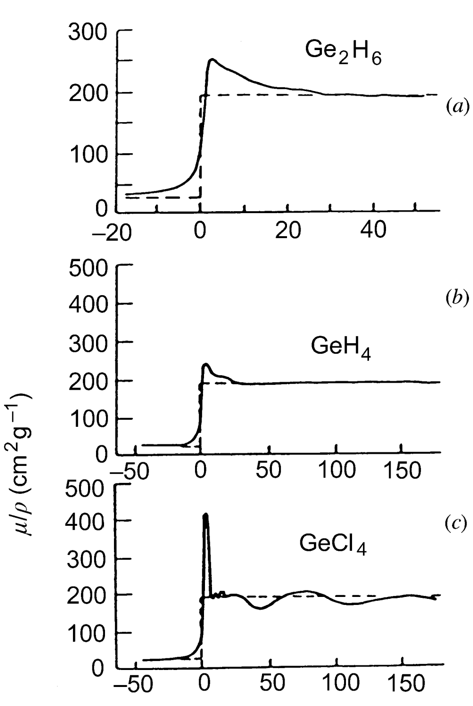

Fig. 4.2.3.2. The dependence of the X-ray attenuation coefficient on energy for a range of germanium compounds, taken in the neighbourhood of the germanium absorption edge (from *IT* IV, 1974).

4.2.3.2. *Techniques for the measurement of X-ray attenuation coefficients*

4.2.3.2.1. *Experimental configurations*

Experimental configurations that set out to determine the X-ray linear attenuation coefficient μ_l or the corresponding mass absorption coefficients (μ/ρ) must have characteristics that reflect the underlying assumptions from which equation (4.2.3.1) was derived, namely:

(i) the incident and transmitted beams are parallel and there is no divergence in the transmitted beam;

(ii) the photons in the incident and transmitted beams have the same energy;

(iii) the specimen is of sufficient thickness.

Because of the considerable discrepancies that often exist in X-ray attenuation measurements (see, for example, *IT* IV, 1974), the IUCr Commission on Crystallographic Apparatus set up a project to determine which, if any, of the many techniques for the measurement of X-ray attenuation coefficients is most likely to yield correct results. In the project, a number of different experimental configurations were used. These are shown in Fig. 4.2.3.3. The configurations used ranged in complexity from that

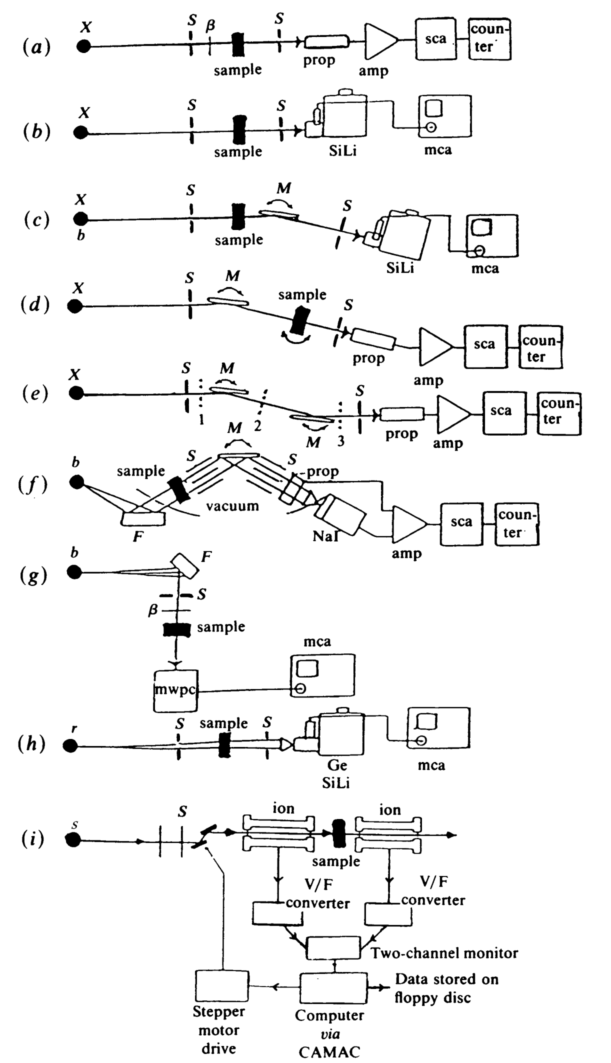

Fig. 4.2.3.3. Schematic representations of experimental apparatus used in the IUCr X-ray Attenuation Project (Creagh & Hubbell, 1987; Creagh, 1985). *X*: characteristic line from sealed X-ray tube; *b*: *Bremsstrahlung* from a sealed X-ray tube; *r*: radioactive source; *s*: synchrotron-radiation source; β: β-filter for characteristic X-rays; *S*: collimating slits; *M*: monochromator.

 references