# Progress Report to E.A.N.D.C.

## from Sweden, April 1965

edited by

N. Starfelt

AB Atomenergi, Studsvik, Nyköping

## A. Work done at the Research Institute of National Defence, Stockholm

### 1. $\bar{\nu}$-measurements in the fast neutron fission of $U^{235}$, $Pu^{239}$ and $Pu^{241}$

H. Condé, M. Holmberg

Average number of neutrons from the fission of $U^{235}$, to be published in Arkiv Fysik.

Measurements of the average number of prompt neutrons per fission are in progress for $Pu^{239}$ and $Pu^{241}$ using a large liquid scintillator as the fission neutron detector. For $Pu^{239}$ the incident energy region from 4 - 14 MeV and for $Pu^{241}$ from thermal to 14 MeV will be measured.

### 2. $\bar{\nu}$-measurements in the photofission of $U^{238}$

M. Holmberg, H. Condé

A measurement of prompt $\bar{\nu}$ for photofission of $U^{238}$, to be published in Arkiv Fysik.

### 3. Fission neutron spectrum

H. Condé, G. During

Fission neutron energy spectra of $U^{235}$, $Pu^{239}$ and $Cf^{252}$, to be published in Arkiv Fysik.

Measurements of the fission neutron spectra in the neutron induced fission of $U^{235}$ and $Pu^{239}$ and in the spontaneous fission of $Cf^{252}$ have been made.

| Nuclide | Incident Neutron Energy MeV | Maxwellian Temperature T (MeV) |
|---|---|---|
| $U^{235}$ | 0.04 | 1.24 ± 0.04 |
| | 1.50 | 1.25 ± 0.04 |
| $Pu^{239}$ | 0.04 | 1.34 ± 0.04 |
| $Cf^{252}$ | Spont. | 1.39 ± 0.04 |

### 4. Measurement of the $Be^{9}$ (n,2n) cross section

H. Condé, M. Holmberg, E. Möller, AB Atomenergi

Using a large liquid scintillator as the neutron detector a measurement of $Be^{9}$ (n,2n) cross section in the threshold region is in progress.

## 5. Proportional counters for measurements of continuous neutron spectra in the 0.05 to 10 MeV range

B. Brunfelter, J. Kockum

a) Spherical hydrogen filled detectors with different pressure is being used to measure fast reactor spectra between 0.05 and 1 MeV.

b) The response of a cylindrical $He^3$ counter to monoenergetic neutrons has experimentally been determined showing pronounced anisotropy effects. The intention is to use spherical counters instead. A computer program to calculate the response for cylindrical and spherical counters is under development taking the (n,p)-reaction, elastic scattering and wall effects into account.

## 6. Elastic scattering angular distributions in the 100 keV region

L.G. Strömberg, S. Schwarz

Using time-of-flight technique and a $Li^6$-loaded glass scintillator as a neutron detector measurements at neutron energies around 100 keV are in progress for $U^{238}$. The measurements will be extended to other elements.

## 7. Inelastic neutron scattering of 95 keV neutrons from the 45 keV level in $U^{238}$

L.G. Strömberg, S. Schwarz

FOA 4 report A 4414-411 (1965) (submitted to Nucl. Phys.)

The cross section for inelastic scattering from the first excited (rotational) level in $U^{238}$ has been studied for 95 keV incident neutron energy. The experiment was performed by a time-of-flight method with a $Li^6$-glass scintillator detector. The result obtained is $\simeq$ 60 mb with a statistical error of ~ 150 mb. This should be compared to the cross section of $\simeq$ 450 mb expected from statistical model calculations based on experimental results obtained at higher energies.

The measurements will be extended to other heavy nuclei to determine the influence of nuclear level width fluctuations.

8. A relative measurement of the $Li^6(n,\alpha)H^3$ cross section

S. Schwarz, L.G. Strömberg, A. Bergström

Nucl. Physics 63, 593 (1965).

The $Li^6(n,\alpha)H^3$ cross section has been measured with a time-of-flight technique using a $Li^6$-glass scintillator as a detector of neutrons produced by the $Li^7(p,n)Be^7$ reaction. In the low energy range the results are based on the assumption that the neutrons from the latter reaction are isotropically distributed in the center-of-mass system for proton energies close to the neutron threshold. In the higher energy range the measurement is based on the (n,p) scattering cross section. A fit according to the Breit-Wigner single level dispersion theory has been made for the p-wave resonance at $E_n \approx 0.25$ MeV taking into account the 1/v dependence of the cross section at low energies, extrapolated from the thermal value.

9. Angular distributions of neutrons from the $Li^7(p,n)Be^7$ reaction near threshold

L.G. Strömberg, S. Schwarz, L. Wallin

FOA 4 report C 4194-411 (1965) (preliminary report)

Angular distributions are presented for neutrons from the reaction $Li^7(p,n)Be^7$ at proton energies between reaction threshold and about 2.3 MeV. A $Li^6$ glass scintillator and time-of-flight techniques were used for neutron detection. The integrated differential cross sections were normalized to published total cross section results. Legendre polynomial expansions and theoretical interpretation are in progress.

10. Angular distributions of neutrons from the $Be^9(p,n)B^9$ reaction near threshold

L.G. Strömberg, S. Schwarz

Measurements and theoretical interpretation are in progress. Same techniques as $Li^7(p,n)Be^7$ measurements.

11. Experimental fast neutron spectra in U

G. During, R. Jansson

Data treatment on neutron spectra from the bombardment of uranium with 3 and 15 MeV neutrons are in progress.

## 12. γ-Rays from Fast Neutron Capture

B. Lundberg, N. Starfelt, AB Atomenergi

Measurements have been completed for Rb, Sr, Y, Zr and Nb for 0.03 to 1.5 MeV neutrons. The results are beeing prepared for publication.

## B. Work done at the reactor R1, Stockholm

### 1. Thermal neutron capture gamma rays at R1, Stockholm

R. Hardell, S.E. Arnell, Chalmers University of Technology

A three crystal pair spectrometer is used for the detection of thermal neutron capture gammas from a target centered in a through channel in the reactor. As a first step to reduce the strong background radiation a long collimator with a cylindrical hole of diameter 6 mm was used to prevent the detector from seeing the reactor channel. The main background source was then found to be capture gammas from nitrogen in the air in the channel. Recently a tube which can be evacuated has been inserted in the reactor, thereby reducing the background to a very low level. The relatively high efficiency of the experimental arrangement makes measurements possible for targets of natural elements of low cross sections as well as separated isotopes of moderate cross sections, available only in small quantities. The measurement of capture gammas from $F^{19}(n,\gamma)F^{20}$ using a teflon target exemplifies the first case, the cross section being only 0.009 b. The other case is represented in a paper in progress on the capture gammas from $Fe^{54}(n,\gamma)Fe^{55}$. The thermal neutron cross section is 2.8 b and the available $Fe^{54}$ quantity is 0.2 g.

The development of Ge solid state detectors has made it desirable to complement the present equipment by exchanging the central NaI detector for a Ge detector. The loss of efficiency due to the small dimensions of this detector and the low absorption coefficient of germanium will probably make it necessary to use both detectors alternatively.

References

1. S.E. Arnell and E.G. Nadjakov, Thermal neutron capture gammas measured with a three crystal pair spectrometer with internal target, Nucl. Instr. & Meth., 24, 185 (1963)

2. E.G. Nadjakov, Neutron capture gamma rays of $F^{20}$, Nucl. Phys., 48, 492 (1963)

3. R. Hardell, S.E. Arnell and P. Blichert-Toft, Thermal neutron capture gammas from $Fe^{54}(n,\gamma)Fe^{55}$, to be published

## 2. Cold neutron scattering at the R1 reactor

U. Dahlborg, AB Atomenergi, and K.E. Larsson, Royal Institute of Technology

During the period the measurements have been performed along the same lines as earlier. In order to understand the connections between the hydrogen bonding and the viscosity in liquids a detailed study on propyl alcohol, $C_3H_7OH$, has been started. In this liquid as well as in glycerol the viscosity varies with many powers of ten from the melting point, -127 °C, to the boiling point, 97 °C. It can be mentioned that the "diffusion coefficients" obtained from the broadening of the quasi-elastic peak follow a smooth curve in the temperature region hitherto studied (-55 °C to +50 °C). This result is different from that obtained from glycerol and may be due to existence of only one single hydrogen bond in propyl alcohol as compared to three in glycerine. The measurements are planned to be continued at lower temperatures.

The preliminary measurements on solutions of heavy water and glycerine have showed some interesting results. If heavy water is mixed into glycerine, a drastic change of viscosity occurs. At low temperatures the first preliminary results on a solution of 20 % $D_2O$ and 80 % glycerine indicate that the diffusion coefficient and the relaxation time seen by the neutron is independent of the viscosity. The measurements are planned to be extended to other temperatures and percentages of heavy water.

Reports

1. U. Dahlborg, K.E. Larsson and D. Jovic, Collective atomic motions in liquid aluminium studied by cold neutron scattering. Presented at the IAEA "Symp. on the Inelastic Scattering of Neutrons" Bombay 1964

2. U. Dahlborg, K.E. Larsson and K. Sköld, Slow neutron spectrometers at the Swedish reactors. Presented at the IAEA "Symp. on the Inelastic Scattering of Neutrons" Bombay 1964 and "Research Reactor Experimental Techniques" Bukarest 1964.

## C. Work done at the reactor R2, Studsvik

### 1. Time-of-flight spectrometer at R2

K. Sköld

The work on solid and liquid argon, the first part of which has been reported in Phys. Rev. Letter (29 June, 1964) and described in full at the Bombay conference (December 1964), has been continued. The experiment is nearly finished and the data are being analysed. It seems possible to obtain valuable information about the coherent scattering and thereby about the nature of the collective motions of the atoms.

Facilities for irradiation of an Al single crystal have been constructed and measurements on the crystal before and after irradiation with fast neutrons (dose ~ $5 \cdot 10^{19}$ neutrons) will be performed..A container for water at 2000 atm is under construction and experiments on water under a variety of conditions will be started within a few months.

### 2. Crystal spectrometer R2

G. Nilsson and R. Stedman

Measurements are being carried out on phonons in lead at 80 $^{o}$K. Dispersion curves for the symmetry directions show only minor differences from those reported by Woods (cf. AECL-1571). More detailed measurements of particular features are now in progress. A first result here is a determination of the radius of the Fermi surface in the (1, 1, 0) direction:
$\rho_F = 3.03 \pm 0.02$ Å$^{-1}$.

The data for aluminium have been treated by an interpolation process to obtain phonon frequencies for all wave vectors, and this complete description of the dispersion relation has then been used to obtain the phonon frequency distribution.

Work on the design of the new spectrometer has advanced to the stage where final drawings can be made.

An investigation of the effect of hot pressing on the mosaic width of germanium crystals was terminated when it became clear that plastic flow in a slab pressed between plates leads to highly uneven deformation (flow at the edges is much more pronounced, and leads to visible crystal damage even for small test pieces). Other ways of deforming a germanium crystal are to be examined, with a view to obtaining a Ge (1, 1, 1) analyzer without second-order reflection.

## 3. A double flat crystal diffraction spectrometer for (n,γ)-studies

B. Lundqvist and S. Nilsson, Chalmers University of Technology

A crystal diffraction spectrometer using two flat crystals has been built. It is used at the R2 reactor ($10^{14}$ n, $cm^{-2}$, $s^{-1}$) in Studsvik. The target is placed in the center of a horisonthal through channel which runs tangentially to the reactor core. The spectrometer is completely automated with a precision of approximately 0.2 sec of arc. Out medium is tape on which are punched the angular position and the number of gamma counts. Smallest angular steps 0.1 sec of arc. Quartz and germanium are used as diffraction crystals. Resolution is 0.3 % at about 500 keV.

Report

1. B. Lundqvist and S. Nilsson, A Double Flat Crystal Spectrometer for (n,γ) Studies. Swedish Research Councils' Laboratory Report LF-10, 1964

## 4. γ-Ray Transition Probabilities

S. Malmskog

An experimental study of some hindered El-transitions in the deformed mass region has been performed using the delayed coincidence technique together with a fast rabbit system connected to the reactor R2-0 at Studsvik. The half lives of some excited levels in $Eu^{155}$, $Tb^{161}$, $Yb^{177}$ and $Hf^{179}$ have been measured from which the absolute gamma transition probabilities have been deduced. The experimental result has been compared with the Weisskopf and Nilsson calculations. To improve the experimental equipment we plan to incorporate a Gerholm-type lens spectrometer into our delayed coincidence spectrometer.

A study of all experimentally known absolute transition probabilities in the deformed mass regions have been performed. Some systematic features have been observed. These can to some extent be explained by pairing correlation and Coriolis admixtures.

A Ge(Li)-gamma detector has been incorporated into the fast rabbit system. We intend to study short lived activities produced by reactor neutrons. The first measurement has been devoted to the study of gamma rays following the decay of $Nd^{149}$.

Reports

1. S.G. Malmskog, Absolute El-transition probabilities in the deformed nuclei $Yb^{177}$ and $Hf^{179}$. Nuclear Phys. 62 (1965) 37

2. S.G. Malmskog, Hindered El-transitions in $Eu^{155}$ and $Tb^{161}$. AE-179 (to be published in Nuclear Physics)

3. K.E.G. Löbner and S.G. Malmskog, Systematics of absolute gamma ray transition probabilities in deformed odd-A nuclei (to be published in Nuclear Physics)

## 5. The life time of the 396.1 keV level in $Lu^{175}$

S. Hellström and S. Malmskog

A report is in preparation.

## 6. $Nb^{93}$-monitors for high neutron dose measurements

S. Hellström

The neutron detectors used in the irradiation of $Nb^{93}$-foils have been measured and the spectrum points calculated by the AGASP-2 programme.

## 7. Thermal neutron flux measurements

S. Hellström

A report on the application of scintillators as β-detectors in the $4\pi\beta$-$\gamma$-coincidence measurement of $Au^{198}$-activity in gold foils is in preparation.

## 8. The double-focusing beta-spectrometer at R2 (Studsvik)

A. Bäcklin, K. Korkman and H. Solhed, University of Uppsala

A double-focusing beta-spectrometer (mean radius 50 cm)[1] has been set up at a neutron-beam from the reactor R2. A 10 mm $H_2O$ scatterer in a tangential channel gives a beam of thermal neutrons, 5 x 5 cm, $1.3 \times 10^8$ neutrons/$cm^2$, sec, at the source-position in the spectrometer. The spectrometer is used for two kinds of measurements:

### A) (n,e⁻)-spectra

The prompt internal-conversion spectrum from neutron-capture in thin target materials is analysed. Measurements have been made in $Cd^{113}(n,\gamma)Cd^{114}$ [2]. Measurements are beeing made in $Dy^{162}(n,\gamma)Dy^{163}$. A method to obtain the level-scheme from a complex spectrum has been developed.

### B) Internal-conversion spectra from isotopes with short half-life

An investigation of the internal conversion spectrum from $Nd^{149} \rightarrow Pm^{149}$ has been undertaken. A great number of lines have been recorded with a resolution of 0.25 percent FWHM.

### Reports

1. G. Bäckström, A. Bäcklin, N.E. Holmberg and K.-E. Bergkvist, Nuclear Instr. 16, 199 (1962).

2. A. Bäcklin, N.E. Holmberg and G. Bäckström, to be published.

## D. Work done at the Van de Graaff laboratory, Studsvik

### 1. The optical model applied to elastic scattering of fast neutrons from natural copper

B. Antolković, B. Holmqvist and T. Wiedling

Angular distributions of neutrons elastically scattered from natural copper have been observed at the energies 1.2, 2.0, 2.5, 3.0, 3.5, 4.0, and 4.5 MeV with a time-of-flight spectrometer. The angular distribution data have been collected at fifteen angles from 20° up to 160° in the laboratory system.

The experimental angular distributions were corrected for anisotropy of the primary neutron source, attenuation of the neutron flux in the scattering sample, and for multiple elastic scattering using a Monte-Carlo computer program. The corrected distributions are obtained in the form of Legendre polynomials $\frac{d\sigma}{d\Omega}(\theta_{cm}) = \sum_{\ell=0}^{n} A_\ell P_\ell(\cos\theta_{cm})$ expressing the differential cross sections. The coefficients are given in Table 1. The errors indicated are statistical.

Table 1. Legendre polynomial coefficients, $A_\ell$, in mb/sr as a function of the neutron energy.

| $E_n$ MeV | $A_o$ | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | $A_6$ | $A_7$ |
|---|---|---|---|---|---|---|---|---|
| 1.5 | 187±5 | 147±11 | 189±15 | 131±19 | 49±19 | | | |
| 2.0 | 180±3 | 192± 6 | 223± 9 | 229±10 | 72±13 | 17±10 | | |
| 2.5 | 160±3 | 196± 4 | 246± 5 | 259± 5 | 136± 5 | 10± 6 | | |
| 3.0 | 148±4 | 216± 9 | 262±13 | 291±13 | 175±15 | 29±11 | | |
| 3.5 | 145±5 | 242±12 | 300±17 | 326±18 | 234±17 | 64±14 | 26±11 | |
| 4.0 | 140±6 | 266±15 | 337±22 | 364±26 | 280±25 | 126±24 | 67±19 | |
| 4.5 | 147±2 | 297± 4 | 379± 6 | 398± 7 | 329± 7 | 162± 7 | 79± 6 | 22± 5 |

Theoretical angular distributions have been fitted to the experimental distributions using the optical model. The optical model potential is given by

$$V(r) = Uf(r) + iWg(r) + U_{SO}\frac{1}{r}\frac{d}{dr}|f(r)|$$

where U, W, and $U_{SO}$ are the real, imaginary, and spin-orbit potential depths. f(r) and g(r) are the Saxon-Woods and derivative Saxon-Woods (surface-peaked) form factors where $f(r) = [1 + \exp(r-R_1)/a]^{-1}$ and $g(r) = 4\exp\{(r-R_2)/b\} \cdot [1 + \exp(r-R_2)/b]^{-2}$. a and b are the surface diffuseness parameters, and $R = r_o A^{1/3}$ is the nuclear radius.

The following parameters were kept constant in the calculations: $a = 0.66$ fm, $b = 0.48$ fm, $R_1 = 1.288\ A^{1/3}$ fm, and $R_2 = 1.250\ A^{1/3}$ fm.

The Abacus 2 computer program was used to find the values of U and W which gave the best fittings to the experimental distributions when $U_{SO}$ was constant. The values of U, W, and $U_{SO}$ as a function of the neutron energy are given in Table 2.

Table 2.

| $E_n$ | MeV | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 |
|---|---|---|---|---|---|---|---|---|
| U | MeV | 47.2 | 46.0 | 46.4 | 46.4 | 46.2 | 45.6 | 45.8 |
| W | MeV | 7.2 | 7.0 | 7.6 | 9.4 | 8.8 | 10.0 | 10.0 |
| $U_{SO}$ | MeV | 12.0 | 12.0 | 12.0 | 10.0 | 8.0 | 4.0 | 0 |

## 2. Neutron Thermalization

E. Möller

Time-dependent neutron spectra in heavy water (99.5 %) have been studied by the use of the pulsed source technique. The reaction rate between the flux and dissolved spectrum indicators (indium, cadmium and gadolinium) has been measured as a function of time by the detection of capture gamma rays from the reaction during the time for the moderation. The indium measurements show the time-dependence of the neutron density at 1.46 eV. The maximum occurs at the time 7 μs after the injection, in good agreement with theoretical predictions by von Dardel. From the cadmium measurements, a preliminary value of the time constant for thermalization of 30 μs has been obtained. The thermalization has been completed after 200 μs. The spatial dependence of the reaction rate curves is quite large and has been investigated for all three indicators. The distribution of slowing-down times to 5.0 and 1.5 eV has also been studied by Monte Carlo calculations by means of an existing Mercury computer program. The results are well reproduced by von Dardel's trial function. The presence of oxygen and light hydrogen decreased the slowing-down time only slightly.

## 3. Scattering of polarized neutrons

O. Aspelund and J. Higbie

The experimental activity was directed towards investigations on the predicted intermediate structure in the energy dependence of the fast-neutron interaction with complex nuclei. As reported previously*, our

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* O. Aspelund, Compt. Rend. Congr. Int. Phys. Nucl., Volume II, 737-740 (Editions du Centre National de la Recherche Scientifique, Paris, 1964)

measurements indicated a positive effect in the energy variations of the left-right ratios of Cu and Mo. We therefore completed our measurements on these nuclei between 1 and 2 MeV, where we now have available complete angular distributions at 9 fast-neutron energies.

However, Cu and Mo suffer from the drawback that the absolute values of their polarizations are rather small. Measurements were therefore initiated on Pb and Bi, and in particular Pb showed a clear-cut effect. Based on our complete angular distributions of the polarization at 12 neutron energies between 1 and 2 MeV.

We are now safe to report on the existence of an intermediate structure in polarized fast-neutron scattering off Pb. The correlated energy behaviour at widely different scattering angles is striking, showing that the observed fluctuations are not of the Ericson type. Moreover, the Ericson fluctuations cannot be seen in the reported measurements, because of the rather large energy spread of the incident fast-neutron beam. On the other hand, the observed structure is definitely not the gross structure predicted by the optical model.

The measurements in Bi have not yet been sufficiently analysed for definite conclusions to be drawn, but preliminary inspections of our data reveal on intermediate structure also in this case. Further work in the lead region is planned.

The experimental routine has been substantially simplified and speeded up after the introduction of automatic data acquisition by means of the RAMSES system.

Work has also been expended on a digital computer program that will correct both for multiple scattering and finite-geometry effects. To this end a polarization-dependent multiple scattering routine has been prepared, and at present a detector routine is beeing made.

Reports

1. O. Aspelund, A General Formalism for Numerical Evaluation of the Polarization of Fast-Neutrons by Means of Finite-Geometry Measurements of the Left-Right Ratio. (FFN-5)

2. O. Aspelund, J. Björkman, and G. Trumpy, An Electro-magnet for Precession of the Polarization of Fast-Neutrons. (FFN-11)

## 4. Neutron energy spectra in (n,n') reactions

I. Bergqvist, B. Lundberg, Research Institute of National Defence
L. Nilsson and N. Starfelt

Preliminary measurements at neutron energies of 7.5 and 8 MeV have been made for the elements Ta, Hg, Pb and Bi. Neutrons were produced through the $D(d,n)He^3$ reaction in a deuterium gas target. By the use of the post acceleration pulsing system it was possible to produce neutron pulses of a duration of 4 ns without increasing the background considerably. The energy of the scattered neutrons was measured by time-of-flight techniques.

In addition to the well-known evaporation spectrum strong neutron groups to excited states at 2.6 and 4.2 MeV were observed in Pb.

## 5. γ-ray spectra in (n,n'γ) reactions

I. Bergqvist, B. Lundberg, Research Institute of National Defence
L. Nilsson and N. Starfelt

Measurements have been made at neutron energies of 5.8 and 7.5 MeV for the elements Fe, Ni, Cu, Zr, Ag, I, Ta, W, Au, Hg, Pb and Bi. A 5" NaI crystal was used as a γ-ray spectrometer. The γ-rays were separated from the background of scattered neutrons by time-of-flight techniques. In several elements strong γ-ray lines or groups of lines were observed in the energy region 3 to 5 MeV. γ-ray strength functions will be deduced from the measured γ-ray spectra.

## 6. γ-ray spectra in (n,γ)-reactions

I. Bergqvist, B. Lundberg, Research Institute of National Defence
L. Nilsson, N. Starfelt

γ-ray spectra emitted in the capture of 7.5 MeV neutrons in Ni, Ag, I, Au, Pb, Bi and U have been measured in Studsvik. The spectral shape differs for all elements very much from predictions based on compound nuclear theory. This indicates that direct capture is of importance at a neutron energy of 7.5 MeV.

## 7. Angular distribution of γ-rays from $Li^7(p,\gamma)Be^8$

I. Bergqvist, Research Institute of National Defence
L. Nilsson

Measurements of the angular distribution, started in Lund, have been completed in Studsvik for proton energies up to 2.6 MeV. Time-of-flight technique was used to reduce the background from neutrons. A 5" NaI crystal was used as γ-ray detector.

## 8. Time-of-flight measurements of neutrons from the (d,n)-reaction in Ca-isotopes

L. Nilsson, N. Starfelt
Z. Sawa, Research Institute for Physics, Stockholm

The spectra of neutrons emitted in the $Ca^{42}(d,n)Sc^{43}$ and $Ca^{44}(d,n)Sc^{45}$ reactions have been measured at a bombarding energy of 5.0 MeV for angles ranging from $17^\circ$ to $70^\circ$. The neutron energies were measured by time-of-flight techniques over a flight path of about 7 m and with a time resolution of 3 ns. The neutron detector was a 2" x 5" plastic scintillator. A number of peaks were resolved in the spectra, some of which could be identified with transitions to known low-lying states in $Sc^{43}$ and $Sc^{45}$.

## 9. Mössbauer effect studies

R. Wäppling

A generally applicable Mössbauer spectrometer has been constructed and test measurements have started on $Fe^{57}$. The velocity drive consists of a double loudspeaker connected to a feed-back amplifier and works with low distortion parabolic motion over a wide velocity range. A multi-channel analyser working as multiscaler is used for data collection and also controls the motion of source relative to absorber or scatterer through pulses from the address-scaler. The instrument is equipped with a helium cryostat and is intended primarily for studies of magnetic properties of nuclear levels as well as magnetism itself.