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Report Of The First Stage In The Co-ordination Of The FLNP/JINR  
and NEANSC (\*) 6th Sub-group Activities In The Delayed Neutron  
Data Field

Dubna : 12 April 1993

1. A first meeting was held, from 5 to 9 April 1993, in the Frank Laboratory of Neutron Physics (FLNP) of the Joint Institute for Nuclear Research (JINR) in Dubna, between :

- the team of the FLNP involved in the Delayed Neutron (DN) data measurements, and,
- the representative ( co-ordinator ) of the NEANSC's (\*) international working group ( the 6th sub-group ) of evaluators in the DN and related reactor Kinetic Parameters field,

The list of the participants is given at the end of this note. ( §6 )

This meeting, held under the auspices of the IAEA, was completed by a workshop aiming to identify the full potential of the FLNP contribution as well as the main technical and/or organisational problems, particularly in the present international co-operative context.

Firstly, the requirements in DN data for applications and/or for basic physics investigations as well as the main current co-operative work on the related new Measurements, Modelling & Evaluation (MM&E) were reviewed and discussed. They are briefly recalled in the following two paragraphs.

Then, the potential/perspective as well as the current status of the specific FLNP contribution were analysed in detail. The conclusions are reported in the fourth section. Finally in the fifth paragraph some specific practical aspects of the FLNP-6th sub-group co-operation are emphasised, and the participants in the FLNP, DN team are listed.

2. The actual goals of new MM&E for DN data originates in the following requirements :

- 2.1 (a) - to improve the basic existing reactor kinetic parameter, the reactivity scale (beta effective). The current +/- 5% (at 1 sigma) uncertainty, which must be reduced to < +/- 3%, originates principally from the uncertainty in the DN absolute yield (Vd). The current values are :
- +/- 3% for U235 (F and T),
  - +/- 3-6% (following the inducing fission neutron energy) for Pu239,
  - +3% to -6% for U238.

The required precision is better than 3%.

(\*) Nuclear Energy Agency Nuclear Sciences Committee of the OECD

- (b) - related to the new reactor concepts (high burnup, transmutation of high activity transplutonium isotopes, use of some of minor actinides as a 'generator' of neutrons during the transmutation process etc.) one can point out the current uncertainties (of about  $\pm 10\%$ , or higher) for  $V_d$  for the higher plutonium isotopes (Pu240, Pu241, Pu242...) and for the 'minor actinides' (Np237, Am241, Am243, Cm242, Cm243, Cm245). These uncertainties must be reduced to  $\pm 6\%$ .
- (c) - to resolve persistent discrepancies between the proposed different DN temporal group data ( $\alpha k$ ,  $\lambda k$ ). These discrepancies are mainly due to the poor identification of the short lived precursors (loss in counting) and to the loosely defined criteria for the exponential decomposition of the DN precursors accumulating/decay history,
- (d) - to determine the dependence of  $V_d$  on the inducing fission neutron energy (the  $V_d(E_n)$  function). The current  $\pm 4\%$  uncertainty in the range  $0 < E_n < 4 \text{ MeV}$  is unacceptable.

2.2 Besides the 2.1 (a)-(c) 'applicative' requirements it is recognised that a more fundamental approach to the DN emission related topics is also necessary. Briefly :

- (a) - an improved experimentally adjusted modelling of the independent fission yield mass and charge distribution  $Y_i(A, Z)$  could allow a better extrapolation of  $V_d$  for unmeasured fission systems,
- (b) - an improved understanding of the  $Y_i(Z_p)$  distribution and of the Even-Odd (EO) effect dependence on the energy of the fission inducing neutrons, could help to solve the  $V_d(E_n)$  problem.
- (c) - a new accurate measurement/evaluation of the prompt neutron dispersion ('Diven Factor') is needed, particularly for Pu239 and U238. Even if not directly related to the DN emission this factor is essential in  $V_d$  integral (on reactor) measurement using noise techniques (see later).

3. The common strategy adopted by the laboratories involved in the 6th sub-group co-operative work, aiming to satisfy the requirements listed above, is based on some consistent actions (complementary and cross-check) of MM&E in the DN field, at

three levels of refinement :

### 3.1 The Individual Precursor Level - Level 1

At this, the most extensive and physically based level, the problems listed in 2.2 (a) - (c) may be treated.

Currently work is in progress at the Studvik laboratory in Sweden by G. Rudstam and co-workers. New measurements for U238 fission yields have been completed and further measurements for U233 and Th232 are under preparation, with final results being expected by the end of 1994. Improved models of Yi (Z,A,En) and EO (En) are being developed by A. Wahl (Los Alamos and the University of New York) and by M. James and R. Mills at Winfrith (UK).

### 3.2 The Aggregate Precursor Level - Level 2

New measurements of Vd for U235, U238, and of Vd(En) (for  $50\text{KeV} < \text{En} < 5\text{MeV}$ ) are under preparation at the University of Birmingham (D. Weaver and M. Kellett) in co-operation with Cadarache (A. Filip and H.F Pang), and now with FLNP-JINR.

At the same time an improved adjustment of the 'parameter modelling' ('Systematics') for Vd extrapolation for fission systems with scarce measurement and for the Vd(En) function is being researched by A. Wahl (already cited).

Efforts towards a better definition of a standard for a temporal group representation of the DN precursors accumulating/decay history is forseen (Birmingham, Cadarache, Los Alamos).

### 3.3 The Integral Level - Level 3

This important applicative level also provides a method to measure, under particular conditions, the nuclear beta ( $=Vd/Vt$ ) parameters for U235, U238 and Pu239.

A particular set of three fast assemblies are to be realised in the MASURCA facility at Cadarache (France). An international team of experimentators and analysts (France, UK, USA, Japan, Italy, Russia) are participating in the measurement and analysis of results to extract the nuclear beta values using two different and statistically independent techniques.

The important feature of these techniques is to relate simply (proportionality) the basic nuclear data Vd and D (Diven Factor) with integral (reactor kinetic and static) signals (reactivity, transfer function, correlated fission chains coincidence, absolute fission rates).

It is important to emphasise that the three (or four) sources of consistent, but 'statistically independent' information on  $V_d$  obtained from levels 2 and 3 could result in the reduction of the final uncertainty on this parameter by a factor of about  $1/\sqrt{3}$ .

Another important item to be emphasised is the utilisation, by all of the cited laboratories, of the isotope  $U^{235}$  as a common (known) standard (for the measurements of  $V_d$  as well as the  $Y_i(A,Z)$  distribution).

Also, an attempt is being made to measure, via a reactor reactivity transient, the DN precursor decay and to express it in terms of temporal group parameters (consistently with level 2 MM&E).

4. The potential of the FLNP/JINR contribution to the international co-operative work (section 3) is demonstrated by the results already obtained.

The FLNP method of periodical irradiation (MPI) of the target is characterized with small losses of detected delayed neutrons for all groups of precursors and thus can be used mainly for total DN yield measurements. In addition to the above mentioned advantage of the MPI, the main assets of the FLNP method are as follow:

- capability for searching short lived precursors with half-life time less than 200 MS,
- due to the very high reactor neutron flux density, one can measure the  $V_d$  values also for subthreshold fissioned isotopes (NP237, AM241),
- consistency check of measured  $V_d$  values with the Keepin-Tuttle 6 group analysis results.

- 4.1 However to obtain more precision the FLNP aims to reconstruct the experimental facility in order to increase the neutron flux on the sample and suppress the resonance flux background. The reliability of the new arrangement will be tested by measuring the absolute value of  $V_d$  for  $U^{235}$ .

This parameter will serve as a basis for the normalisation and cross-checking of the consistency between the three laboratory performances (FLNP-Birmingham-Cadarache).

The first results are expected at the end of 1993 (with the new collimator, and, perhaps, a new chopper and mirror neutron guide). Simultaneously, measurements with cold neutrons (with an energy of approximately

0.007eV) could also be performed hence, providing new information.

- 4.2 During 1994 other isotopes (Pu239, Np237) are planned to be measured. On the basis of the experience gained, the measurement of other more difficult higher actinides will be envisaged, starting with Am241 and Cm243.
- 4.3 In order to correlate the FLPN thermal measurements with the resonance/fast ones at Birmingham (>50KeV), the FLPN team will study the possibility of mean Vd measurements for the resonance region 0-10KeV on an adapted neutron source (IBR-2 or, more feasibly, the IREN facilities).
- 4.4 At the Level 1 precursor level (see section 2.2) the FLPN will investigate the possibility of using the results from the Yi(Z) measurements to improve the Yi modelling. Co-operation with TU of Dresden (M. Marten) and Los Alamos in USA (A. Wahl) is foreseen.
- 4.5 In the same context the possibility for new measurements of the prompt neutron dispersion factor (Diven Factor) at Dubna will also be examined.

## 5. Practical And Organisational Aspects

- 5.1 Both parties realise the importance of the exchange of information on work progress and on results by letters or by occasional meetings (task sharing).
- 5.2 The FLNP proposes that its representatives participate in the next meetings of the 6th sub-group of NEANSC. The FLNP also proposes to hold one of the next NEANSC 6th sub-group meetings in the FLNP-JINR, DUBNA, RUSSIA.
- 5.3 Both parties emphasised the important role of the IAEA in the overall co-ordination and support.
- 5.4 Considering the importance of the work planned and the related necessary technical support, ways are being sought among the concerned national and international establishments to contribute to the material effort (samples, PC's) and also to meetings.

The FLNP-DN team consists of the following participants:

1. Walter Ilich Furman, Head, Division of nuclear Physics, FLNP
2. Elmir Dermendjiev, representing also the FLNP DN team in the 6th sub-group.
3. Ivan Ruskov
4. Yuri Sergeevitch Zamyatnin, Head, Working group
5. Vladimir Maximovich Nazarov, Head, Working group
6. Sergei Borisovich Borzakov
7. Michail Vladimirovich Lachinov

6. Participants to the meeting

I. FLNP-JINR Team

Walter Ilich Furman  
Elmir Dermendjiev  
Yury Sergeevitch Zamyatnin  
Lev Borisovitch Pikelner  
Vladimir Maksimovitch Nazarov  
Ivan Ruskov  
Mikhail Vladimirovich Lachinov

II. Representative Of The NEANSC 6th Sub-group

Alexandre Filip - CEA, Cadarache