

**NOTES ON THE FRINGE OF THE MEETING :**  
**"COLLOQUY ON DELAYED NEUTRON DATA", HELD IN IPPE,**  
**OBNINSK, RUSSIA, April 1997**

**A. FILIP**

I. Leading items tackled-explicitly or implicitly-in this note are :

1. Distinguish between two domains of interest related to the physics of the Delayed Neutrons (DN) and to the accurate knowledge of the DN Data (DND) :

- the already classical reactor technology, than, upstream, the reactor physics studies, principally through of Fundamental Kinetic Parameters (FKP),
- the fundamental physics studies, namely the fission fragmentation ; the highly excited, neutron rich nuclei ; the astrophysics. This domain is out the scope at this paper.

2. Consider explicitly, but consistently, all the "three levels" of information source and/or application domains of DND and related FKP, t.i. :

- Level 1 : microscopic detailed precursors (FPY,  $P_{n,i}$ ,  $\lambda_i$ ,  $\chi_{di}$ ).
- Level 2 : microscopic aggregate of precurs  $\{(a_k, \lambda_k, \chi_{dk}), v_d\}$ .
- Level 3 : integral  $\rightarrow$  FKP ( $\beta_{eff}$ ,  $\Lambda/\beta_{eff}$ ,  $\rho/\beta_{eff}$  ;  $\bar{\lambda}_d/\beta_{eff}$ ).

The related activities concerning the Measurement, Modelling and Evaluation (MM&E) conducted (currently/historically) more or less independently should be systematically cross-checked in order to insure overall consistency and precision improvement for all - on the three levels - parameter  $\rightarrow$  shortly : "link" the adjacent levels.

The levels 1&2 are linked through "summation" (England/Brady, Blachot, James/Mills/Weaver, What ...).

The link of levels 2&3 is more complex and needs more work for clear definition of some representative ("standard") FKP/DND correlation (ex. g. through the Unified Model by Filip/D'Angelo/Pang).

3. Recognise "degree of priorities" and related time schedule.

4. Correlatively recommend specification for MM&E.

II. First priority - schedule - one year

1. Consolidate -as "primary standards"- the status of DN Yields ( $v_d$ ) of principal Fission systems namely U5(F,T), Pu9(F,T), U8(F). New evaluation is necessary accounting for :

- the seldom utilisation of Tuttle evaluation either the 1975 or 1979 ones. The last, beside less optimistic precision, recommends values systematically lower by 2 % to 5,5 %, fact apparently due to the measurements of Besant (1977) claimed as very accurate.

- measurements on level 2, performed after 1977, in particular those in progress at Dubna, Obninsk, Birmingham,
- MM&E on level 3 ( $\beta_{\text{eff}}$ ) through two complementary methods :
  - "global" ( $\beta_{\text{eff}}$ ) E/C minimization (adjustment of  $v_d$  via sensitivity),
  - "detailed" exploitation of all the measurements results in  $\beta_{\text{eff}}$  experiment, together with those from level 2, via the Unified Model, by Filip/d'Angelo/Pang.
- Both methods are currently worked at Cadarache and Casaccia for 13 fast assemblies and should be continued. However for the cases BERENICE (RZ, Z2 on Masurca and XIX on FCA/Tokaimura), the detailed, Unified Model must be applied together with data from level 2.
- For thermal system it is necessary to collect the existing  $\beta_{\text{eff}}$  measurements (including the Japanese homogeneous U5 cores and on going Epicure/Mistral campaign).
- More theoretical work for stochastic  $\beta_{\text{eff}}$  measurement (see also § 2.1).
- However the Fast and Thermal adjustments should be made separately because of the lack of intermediate spectrum experimental basis as well as firm modelling of the incident energy dependence of the  $v_d \rightarrow v_d(E_n)$  [see later the problem of  $v_d(E_n)$ ].

## 2. Reevaluate the temporal group ( $a_k, \lambda_k$ ) and spectra data ( $\chi_{d,k}$ )

### 2.1 ( $a_k, \lambda_k$ ) needs two distinct works :

- a) The consistent normalization of the relative yields  $a_k$  to the absolute value of  $v_d$ , as required in kinetic eqns (e.g. inhour eqn.). The lack of this consistency (as it happens in ENDF/B-VI) causes wrong predictions of the reactivity in \$ (as founded by Spriggs, Tony, Mohaniakrishnan et al).
  - Two ways are to be considered to achieve this consistency :
    - renormalize the "best" relative yields ( $a_k$ ) to the "best" absolute  $v_d$ , evaluated separately,
    - handle the same campaign of measurement (on level 2)  $\bar{v}_d$  as well as the decay  $v_d(t)$  ; this could be made in Dubna and Obninsk campaign.
- b) Better definition of specific kinetic transients in order :
  - to refine the ( $a_k; \lambda_k$ ) recommendation (better link of levels 1&2 and 2&3),
  - to clearly establish the current point kinetic approximation and propose improved models for :
    - high subreactivity states (a new, 7th temporal group  $a_k$  ?),
    - explain discrepancies between deterministic ( $S_{\text{eff}}$ ) and stochastic results (in particular in  $\beta_{\text{eff}}$  measurements). Work in this domain is on going at Cadarache. Resulting models are to be applied in BERENICE and FCA/XIX measurements interpretation.

## 2.2 The spectra $\gamma_d$

Two sources of data are to be considered : MM&E on level 1 and measurements on level 2 by the team of Lowell University. The first source results in the ENDF/B-VI data (work by Brady and England) and second by a tentative to construct six group spectra (Cottrell and al). The two sources should be "linked" in order to propose new data for users.

### III. Second priority → schedule ~ 2 years

1. Concerns MM&E for new projects in reactor technology (burners of Pu and/or transmutation of higher actinides) : Pu241 (for MOX, thermal systems) and, further Np237.
2. MM&E of the function  $v_d(E_n)$  at level 2 for U5, U8, Pu9 in energy ranges :
  - 0.5 to 5 MeV - Birmingham, Obninsk, (others ?),
  - 0 to ~ KeV region - possibly in Dubna.

On the other hand, more work for modelling this function (e.g., developing of the models by Lendel, Pronyaev, ...) should be useful, in particular for link with level 3 ( $\beta_{eff}/v_d$ ).

#### Subsidiary remark

Excepting for the spectra, and may be for the  $v_d(E_n)$  function the level 1 DND accuracies are not sufficient for FKP prediction but, conversely the DND from level 2 should be considered as part and parcel for basic physics studies evoked in § I.1, studies to be lead on levels 1 and 2. However such studies must be considered as specific full activity (a part subgroup ?).