IEC -225

May 2000

20406/00.30919/P

Processing and validation of intermediate energy evaluated data files

Final report of Subgroup 14 of the Working Party on Evaluation Coordination of the Nuclear Science Committee

A.J. Koning
Nuclear Research and Consultancy Group NRG
Petten, The Netherlands

Preliminary version: Open for comments

Abstract

Subgroup 14 of the working party was initiated with the objective to assess the quality and practical use of intermediate energy evaluated data files. The current collection of intermediate energy data files was established, with the criterion being the processability of the data files for current transport codes. The quality of the pointwise data, for neutrons and protons on several isotopes up to 150 MeV, is reviewed. This was done by means of the datafiles themselves, associated cross section plots and outputs of checking codes. In the process, the LA150 library was recommended for inclusion in ENDF/B-VI. An integral transport calculation with MCNPX was performed to validate the files against a neutron transmission experiment.

Contents

1. Introduction

Current accelerator-driven and other intermediate energy technologies require accurate nuclear data to model the performance of the target/blanket assembly, neutron production, activation, heating, and damage. In a previous WPEC subgroup, SG13 on Intermediate Energy Nuclear Data, various aspects of intermediate energy data, such as nuclear data needs, experiments, model calculations, and file-formatting issues have been investigated and categorized to come to a joint evaluation effort. The successor of SG13, SG14 on the processing and validation of intermediate energy evaluated data files, goes one step further. The nuclear data files that have been created with the aforementioned information need to be processed and validated in order to be applicable in realistic intermediate energy simulations. We emphasize that the work of SG14 *excludes* the 0-20 MeV data part of the neutron evaluations, which is supposed to be covered elsewhere. This final report contains the following sections:

- Section 2: A survey of the data files above 20 MeV that have been considered for validation in SG14.
- Section 3: A summary of the review of the 150 MeV intermediate energy data files for ENDF/B-VI and, more briefly, the other libraries.
- Section 4: Validation of the data library against an integral experiment with MCNPX.
- Section 5: Conclusions.

2. Data files above 20 MeV

The various intermediate energy files that have been created have several things in common:

- They are usually created for both incident neutrons and protons.
- They are stored in the ENDF-6 format.
- The usual upper energy limit is 150 MeV, though some files up to 50 MeV (for fusion) exist.
- The part below 20 MeV is usually left untouched, whereas the part above 20 MeV is primarily based on new model calculations, which are guided by the few existing experimental data sets.

Table 2.1 gives the entire collection of intermediate energy data files that is presently known to SG14. The criterion of being included in this table is that the data file has been, or will be in the near future, successfully used in a transport code (in practice, at the moment this means either MCNP-4A/B/C or MCNPX). The following (partial) libraries were considered:

- Los Alamos LA150 data library [1]. This is a neutron and proton library up to 150 MeV for a suite of isotopes. The library has been tested against both microscopic and integral experiments. The LA150 library was produced in collaboration with JAERI, Japan and NRG, Petten.
- NRG/CEA data library [2]. This presently consists of 150 MeV neutron and proton files for the main iron and nickel isotopes. The NRG/CEA library is the result of a collaboration between NRG, Petten and CEA, Bruyères-le-Châtel.
- JENDL/HE library [3]. This is a 50 MeV neutron data library for isotopes relevant for fusion. The library is produced at JAERI.
- IPPE/FZK library [4]. This is also a 50 MeV neutron data library for isotopes relevant for fusion. The library was produced by IPPE Obninsk and FZK Karlsruhe.
- IPPE/KTH library [5]. This consists of 150 MeV neutron and proton files for the main Thorium and Uranium isotopes. This library was produced by IPPE Obninsk and KTH Stockholm for the IABAT project of the EU.

Table 2.1 *Intermediate Energy datafiles, May 2000*

Nuclide	Library	Origin	Particle	Energy	Checked	MCNP	Multigroup
1H	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	yes
	JENDL HE	JAERI	n	50 MeV			
2H	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
C	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
12C		IPPE/FZK	n	50 MeV		yes	
	JENDL HE	JAERI	n	50 MeV			
14N	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
160	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	yes
		IPPE/FZK	n	50 MeV		yes	
23Na		IPPE/FZK	n	50 MeV		yes	
	JENDL HE	JAERI	n	50 MeV			
24Mg	JENDL HE	JAERI	n	50 MeV		yes	
25Mg	JENDL HE	JAERI	n	50 MeV		yes	
26Mg	JENDL HE	JAERI	n	50 MeV		yes	
27Al	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	yes
	JENDL HE	JAERI	n	50 MeV		yes	
28Si	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	yes
		IPPE/FZK	n	50 MeV		yes	
	JENDL HE	JAERI	n	50 MeV		yes	
29Si	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	yes
	JENDL HE	JAERI	n	50 MeV		yes	
30Si	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	yes
	JENDL HE	JAERI	n	50 MeV		yes	
31P	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
35Cl	JENDL HE	JAERI	n	50 MeV			
37Cl	JENDL HE	JAERI	n	50 MeV			
39K		IPPE/FZK	n	50 MeV		yes	
	JENDL HE	JAERI	n	50 MeV		yes	
41K	JENDL HE	JAERI	n	50 MeV		yes	
Ca	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	yes
40Ca	JENDL HE	JAERI	n	50 MeV		yes	
42Ca	JENDL HE	JAERI	n	50 MeV		yes	
43Ca	JENDL HE	JAERI	n	50 MeV		yes	
44Ca	JENDL HE	JAERI	n	50 MeV		yes	
46Ca	JENDL HE	JAERI	n	50 MeV		yes	
48Ca	JENDL HE	JAERI	n	50 MeV		yes	
46Ti	JENDL HE	JAERI	n	50 MeV		yes	
47Ti	JENDL HE	JAERI	n	50 MeV		yes	
48Ti	JENDL HE	JAERI	n	50 MeV		yes	
49Ti	JENDL HE	JAERI	n	50 MeV		yes	
50Ti	JENDL HE	JAERI	n	50 MeV		yes	

Continuation of **Table 2.1.**

Nuclide	Library	Origin	Particle	Energy	Checked	MCNP	Multigroup
50V	JENDL HE	JAERI	n	50 MeV		yes	
51V		IPPE/FZK	n	50 MeV		yes	
	JENDL HE	JAERI	n	50 MeV		yes	
50Cr	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
52Cr	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
		IPPE/FZK	n	50 MeV		yes	
	JENDL HE	JAERI	n	50 MeV			
53Cr	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV			
54Cr	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV			
55Mn	JENDL HE	JAERI	n	50 MeV			
54Fe	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	yes
		NRG/CEA	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
56Fe	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	yes
		NRG/CEA	p,n	150 MeV	yes	yes	
		IPPE/FZK	n	50 MeV		yes	
	JENDL HE	JAERI	n	50 MeV		yes	
57Fe	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	yes
	JENDL HE	JAERI	n	50 MeV		yes	
58Fe	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	yes
	JENDL HE	JAERI	n	50 MeV		yes	
58Ni	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
		NRG/CEA	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
60Ni	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
		NRG/CEA	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
61Ni	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
62Ni	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
64Ni	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
63Cu	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
65Cu	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV		yes	
89Y	JENDL HE	JAERI	n	50 MeV			

Continuation of **Table 2.1.**

Nuclide	Library	Origin	Particle	Energy	Checked	MCNP	Multigroup
90Zr	JENDL HE	JAERI	n	50 MeV			
91Zr	JENDL HE	JAERI	n	50 MeV			
92Zr	JENDL HE	JAERI	n	50 MeV			
94Zr	JENDL HE	JAERI	n	50 MeV			
96Zr	JENDL HE	JAERI	n	50 MeV			
93Nb	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV			
92Mo	JENDL HE	JAERI	n	50 MeV			
94Mo	JENDL HE	JAERI	n	50 MeV			
95Mo	JENDL HE	JAERI	n	50 MeV			
96Mo	JENDL HE	JAERI	n	50 MeV			
97Mo	JENDL HE	JAERI	n	50 MeV			
98Mo	JENDL HE	JAERI	n	50 MeV			
100Mo	JENDL HE	JAERI	n	50 MeV			
180W	JENDL HE	JAERI	n	50 MeV			
182W	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV			
183W	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV			
184W	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV			
186W	ENDF/B-VI	LANL	p,n	150 MeV	yes	yes	
	JENDL HE	JAERI	n	50 MeV			
196Hg	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
198Hg	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
200Hg	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
201Hg	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
202Hg	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
204Hg	ENDF/B-VI	LANL/JAERI	p,n	150 MeV	yes	yes	
206Pb	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	
207Pb	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	
208Pb	ENDF/B-VI	LANL/NRG	p,n	150 MeV	yes	yes	
209Bi	ENDF/B-VI	LANL	p,n	150 MeV			
232Th		IPPE	p,n	150 MeV	no	yes	
238U		IPPE	p,n	150 MeV		yes	

3. Review of the basic data

As argued in several papers (e.g. [1, 2, 6], below 150 MeV the predictive power of several pre-equilibrium/statistical model codes is superior to intranuclear cascade codes for continuum reactions. Also, individual reaction mechanisms (giant resonances, direct collective reactions, etc.) constitute a relatively larger fraction of the reaction spectrum and require an individual, more sophisticated treatment. When results from such detailed reaction mechanisms are collected and included in a datafile, they form a data source that in quality can never be matched by one single computer code. All the physical models that are utilized in the LA150 and NRG/BRC libraries are described in [1] and [2] respectively. Most of the data have been generated with the GNASH and ECIS codes. Refs. [1, 2] contain a large collection of comparisons of the calculated data (which are stored in the file) and the existing experiments. The comparisons include total and reaction cross sections, elastic scattering angular distributions, double differential data and residual production cross section above 20 MeV. The agreement with experimental data ranges from excellent to very reasonable, see the figures in the aforementioned references.

3.1 LA150 library

Subgroup 14 has been asked to review the LA150 library, and to make recommendations concerning inclusion of LA150 in ENDF/B-VI. In the meantime, the adoption of LA150 into ENDF/B-VI has taken place. The CSWEG request came from the Evaluation Committee of ENDF/B-VI, which only concerns itself with "Phase 1" reviews. This means that the present review does not involve integral data testing, but rather is concerned with:

- The correct format of the evaluations.
- Errorless passing of the checking codes.
- Continuous data varying smoothly with energy, angle, etc..
- Agreement with existing measurements.

The two principal authors of the LA150 library, M.B. Chadwick and P.G. Young, have provided Subgroup 14 with the following information:

- Documentation:
  - A recent publication in Nuclear Science and Engineering [1], containing extensive comparisons of the model-based data with measurements.
  - A collection of summary file-1 documentation and benchmark figures (some of them 3D) depicting the data in the libraries [7].
- Data in electronic form:
  - All the evaluated files of LA150.n and LA150.p.
  - Outputs of the BNL checking codes CHECKR, FIZCON, PSYCHE and STANEF.
  - Various postscript plots depicting the data.
  - Summary files of cross sections.

The review has been performed by two parties, JAERI (T. Fukahori) and NRG Petten (A. Koning). Both concluded that LA150 passed the several tests of the "Phase 1" review and that, with some minor modifications, it could be adopted. A few of the findings follow below.

3.1.1 Cross section plots

An extensive collection of figures of total, differential and double-differential data for the LA150 library has been provided in [7]. These figures clearly reveal the overall smooth behaviour of the data as a function of mass, energy and angle. In general, for incident energies between 20 and 50 MeV, the evaporation peak seems to be very pronounced for some (n, xd) data. In particular, there are some, *maybe* anomalous, spikes in the (n, xd) spectra for ^{30}Si, ^{31}P, Ca, ^{60,62,64}Ni , ^{63}Cu (but not in ^{65}Cu) and ^{93}Nb. It is not immediately clear why these peaks appear for these nuclei and this particular channel, whereas they are not present in the (n,xt) and (n,xα) cross sections. Similar spikes appear in ^{28}Si(p, xt) and ^{29}Si$(p, x\gamma)$. The fact that the magnitude of these cross sections is relatively small and that this appears only in a very small energy region means that this is certainly no reason to reject the data files. Of course, the effect may actually be physical. Consult [7] for further details.

3.1.2 BNL checking codes

The output files of the checking codes CHECKR, FIZCON and PSYCHE report several warnings. However these apply almost all at the part below 20 MeV. The only high-energy warning concerns a new feature of ENDF-6, namely the switch from Legendre coefficients to tabular distributions at 20 MeV. The CHECKR code wants this point to be at exactly 20 MeV. The LA150 library gives 20.00001 as the first energy point with tabulated data (and thereby avoids a double point, which seems to be better). Maybe CHECKR requires a little change for this. This warning seems to be a minor detail. table 2.1 shows the datafiles which are known to have been checked this way.

3.2 NRG/CEA library

For this library essentially the same working methods as for LA150 was used. The main difference lies in the use of new optical models throughout the calculation. The checking procedure described for LA150 also applies here. As an example of the contents of the file Fig. 3.1 shows double-differential data for protons on ^{58}Ni.

3.3 JENDL HE library

A comparison of the JENDL HE library with the LA150 and NRG/CEA libraries has been provided by Lee and Fukahori [10]. The conclusions were that JENDL HE generally descibes the data well up to 50 MeV, but that improvements in optical models are required for the most basic cross sections. Also for some materials (notably iron) the double-differential cross sections of LA150 and NRG/CEA seem to do somewhat better than the JENDL HE results. A lot of added value in the JENDL HE library is provided by covering materials that were not (yet) considered in the 150 MeV libraries.

3.4 Processing

Table 2.1 shows that most data files have proven to be processable by NJOY into an MCNP library. In another WPEC document [8], a set of special rules and recommendations for an evaluated nuclear data file are given, such that the above processing conditions are obeyed. Recommendations resulting from that work are:

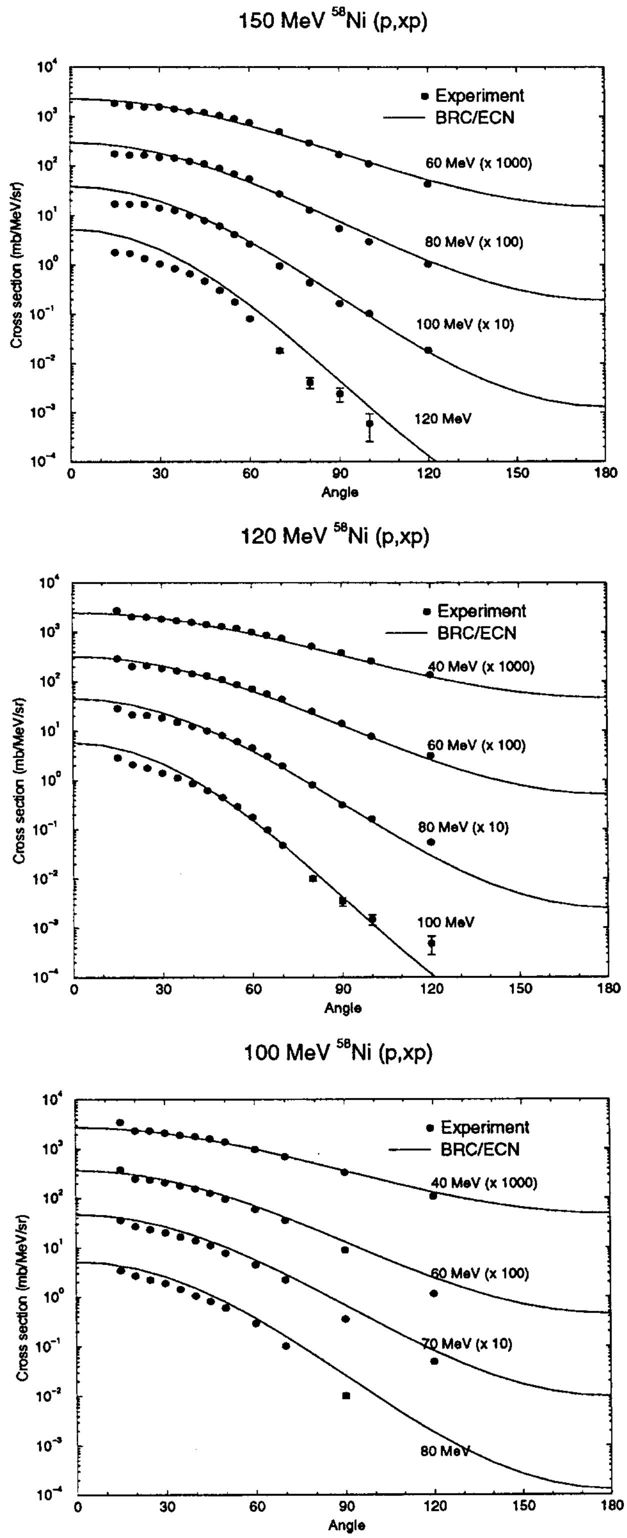

Figure 3.1 *(p,xp) on ^{58}Ni: Comparison between NRG/CEA data file and experimental data [9] for incident energies of, (a) 150 MeV (b) 120 MeV, (c) 100 MeV at several outgoing energies.*

- Use double-points in the MF3 section of the evaluation for the transition of the low-energy range ($E_n < 20$ MeV) to the high-energy range ($E_n > 20$ MeV).
- Double-points should not be used in the MF6 section of the evaluation.
- Use a representation with MT2 (elastic cross section), MT5 ((n, x) cross section), MT18 (fission cross section) and possibly MT101 (neutron disappearance cross section) in the high-energy region.
- Use the redundant production cross sections MT201 to MT207 for the ease of the user: It enables the calculation of production rates in MCNP.
- Specify distributions of reaction products in the MF6 section of the evaluation for MT5.
- If MT18 is used, the MT456 section in MF1 is required.

If these recommendations are followed, high-energy neutron evaluated nuclear data files can be produced which can be used without problems in MCNP(X).

4. Validation with an integral experiment with MCNPX

A number of neutron transmission experiments has been performed [11, 12, 13] at the Azimuthally Varying Field Cyclotron facility at the JAERI Takashi site. Incident 43- or 68-MeV protons impinged on converters consisting of 99.9% enriched ^{7}Li. The ^{7}Li(p,n) reaction produced nearly monoenergetic neutrons, which were then collimated and allowed to strike iron or concrete targets of various thicknesses. The neutron transmission was measured at several positions relative to the transmission target. Although the neutrons were initially almost monoenergetic in all cases, their actual spectra were measured in order to allow for a more realistic comparison with neutron transport calculations. Details about the experimental arrangement and the geometry can be found in the aforementioned references.

This experiment forms an ideal case to validate some of the intermediate energy libraries. The iron isotopes of the Los Alamos 150 MeV library have already been used in an analysis [1] of the 68 MeV experiment. Within SG14, this analysis has been repeated, as an independent check, and extended to other cases. We confirm the overall excellent agreement between the measurements and the data, see figs. 4.1-4.3, that was already reported in [1]. The alternative libraries from NRG/BRC, figs. 4.4-4.6, give an equally good agreement.

It is obvious from figs. 4.7-4.9 that the predictions by LAHET do not have the quality of those using the data libraries. One reason for the deviation from the data is the quality of the elastic scattering model used in LAHET. This is currently under development.

The main reason that we include this comparison with experiment is that we use MCNPX, with the geometrical setup of this experiment, to see whether the *other* isotopes of the LA150 library show any undesired irregularities. This does give a valuable indication of the presence of problems in the evaluations. In figs. 4.10-4.13 the neutron flux at centerline behind a 40 cm slab of pure material is shown. The atomic density at room temperature for all the elements are used. The figures demonstrate that, for this simple experiment, the datafiles do not exhibit any misbehaviour.

An analysis similar to the one described here has been performed by Konno et al [14, 15, 16]. In addition, these authors have perfomed multigroup analyses with the LA150 library (see Table 2.1) using the DORT code and P_9 expanded multigroup libraries. The authors claim that LA150 may have some problems since their MCNP calculations tend to overestimate neutron flux above 10 MeV with an increasing thickness of the assembly. This is an important point for future research. For completeness, we mention that this experiment has also been used to test some of the other libraries [17, 18].

As an alternative manifestation of the impact of the 150 MeV ^{58}Ni evaluation from NRG/CEA we present a calculated result from the TIERCE code system [19], which comprises among others HETC and MCNP-4A. Figure 4.14 displays the neutron flux resulting from a 200 MeV proton beam incident on a 50 cm long ^{58}Ni-cylinder. Two calculations were performed: one with HETC and MCNP+ 20 MeV data file and one with MCNP + 150 MeV data file. Besides the expected discontinuity at 20 MeV for the case with the conventional 20 MeV cutoff, one can observe an overall difference of up to 40 % in the high-energy region.

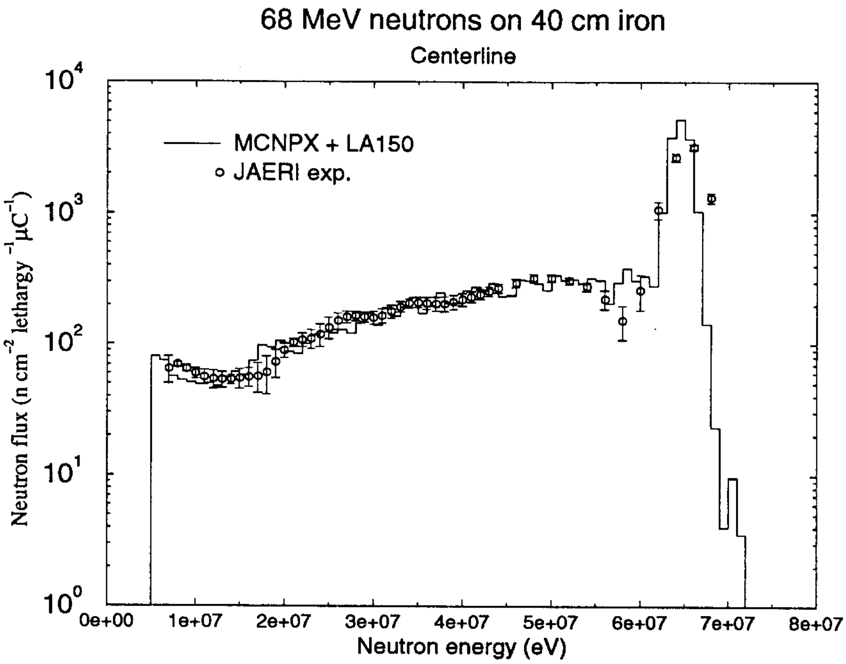

Figure 4.1 *68 MeV neutrons on 40 cm of iron, detector at centerline: Comparison between experimental data and MCNPX + LA150 data libraries.*

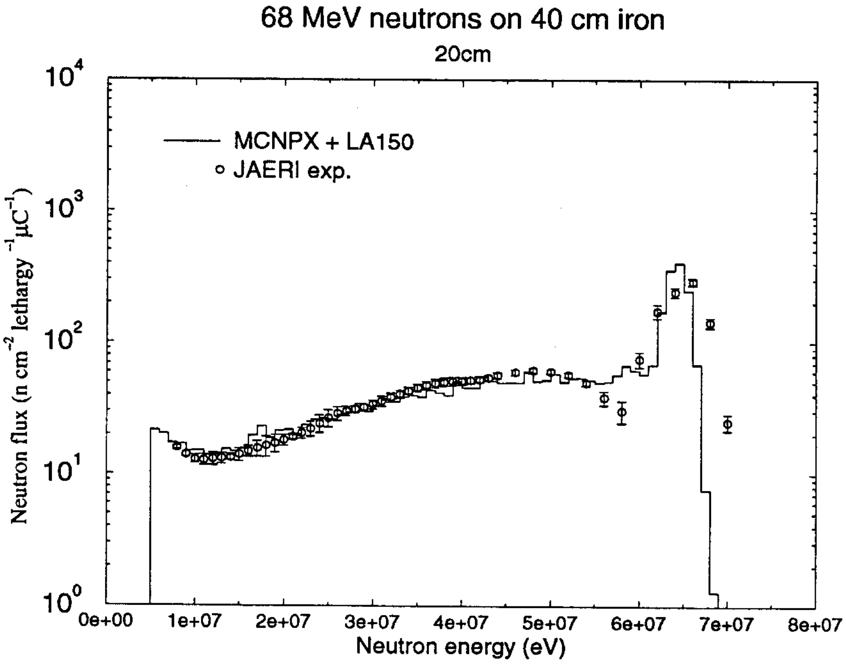

Figure 4.2 *68 MeV neutrons on 40 cm of iron, detector at 20 cm: Comparison between experimental data and MCNPX + LA150 data libraries.*

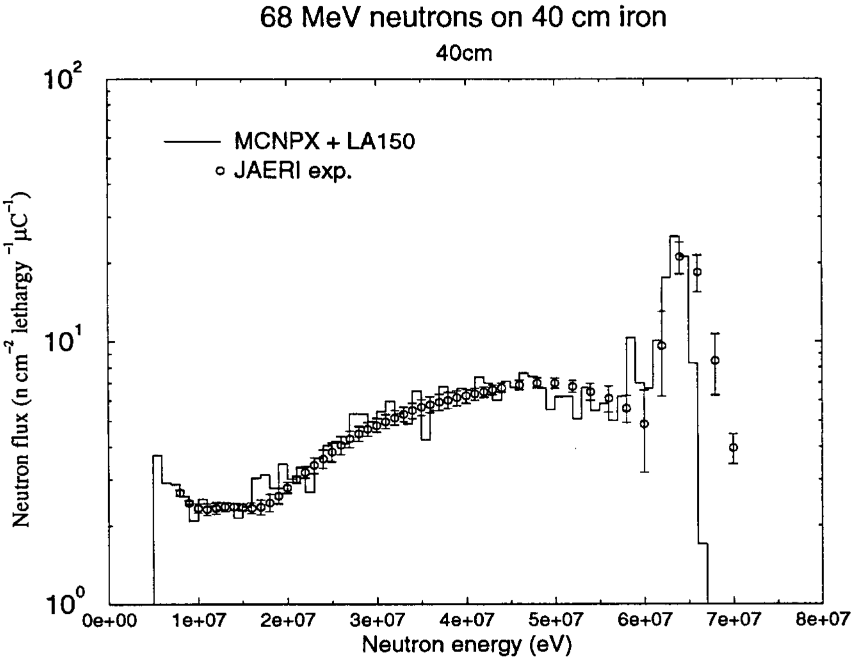

Figure 4.3 *68 MeV neutrons on 40 cm of iron, detector at 40 cm: Comparison between experimental data and MCNPX + LA150 data libraries.*

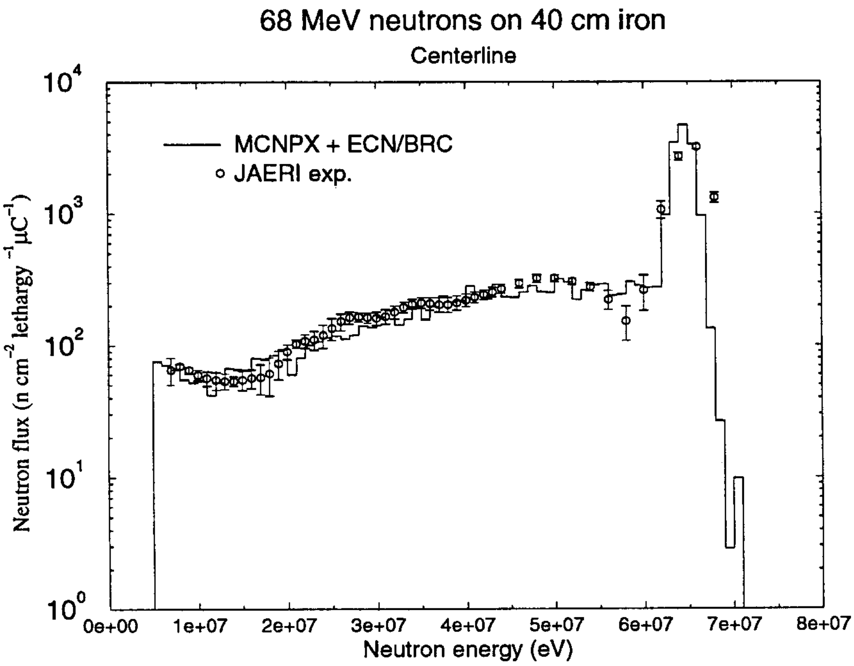

Figure 4.4 *68 MeV neutrons on 40 cm of iron, detector at centerline: Comparison between experimental data and MCNPX + ECN/BRC data libraries.*

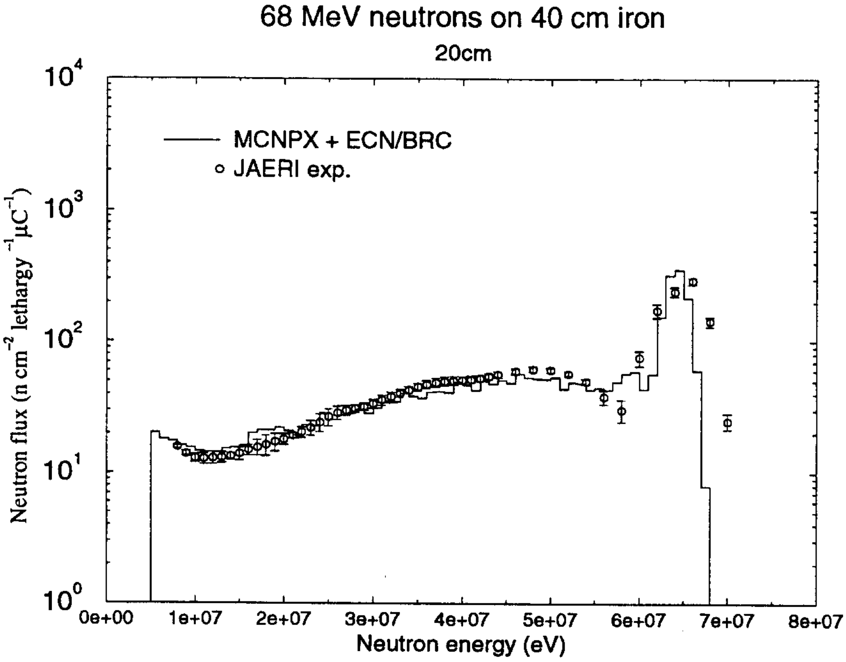

Figure 4.5 *68 MeV neutrons on 40 cm of iron, detector at 20 cm: Comparison between experimental data and MCNPX + ECN/BRC data libraries.*

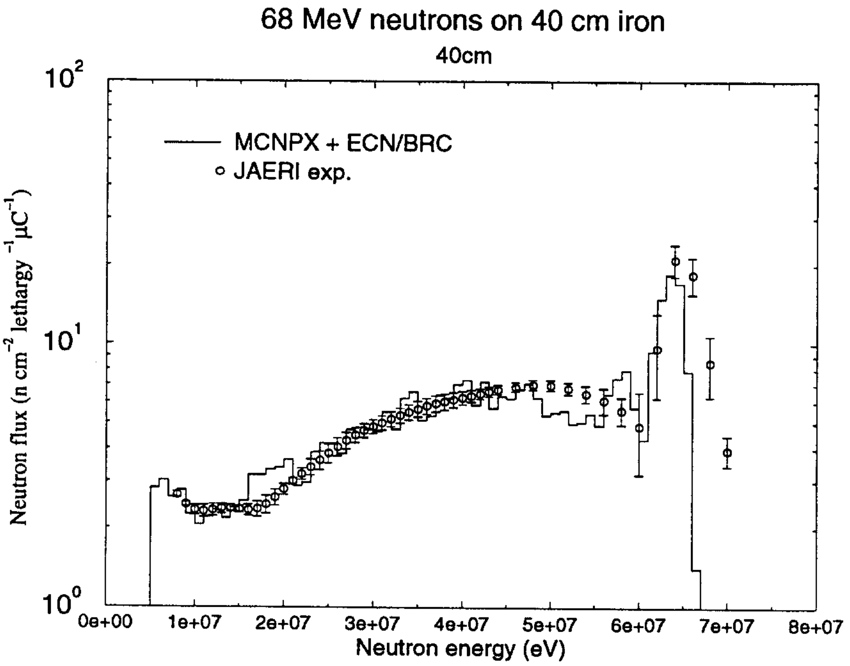

Figure 4.6 *68 MeV neutrons on 40 cm of iron, detector at 40 cm: Comparison between experimental data and MCNPX + ECN/BRC data libraries.*

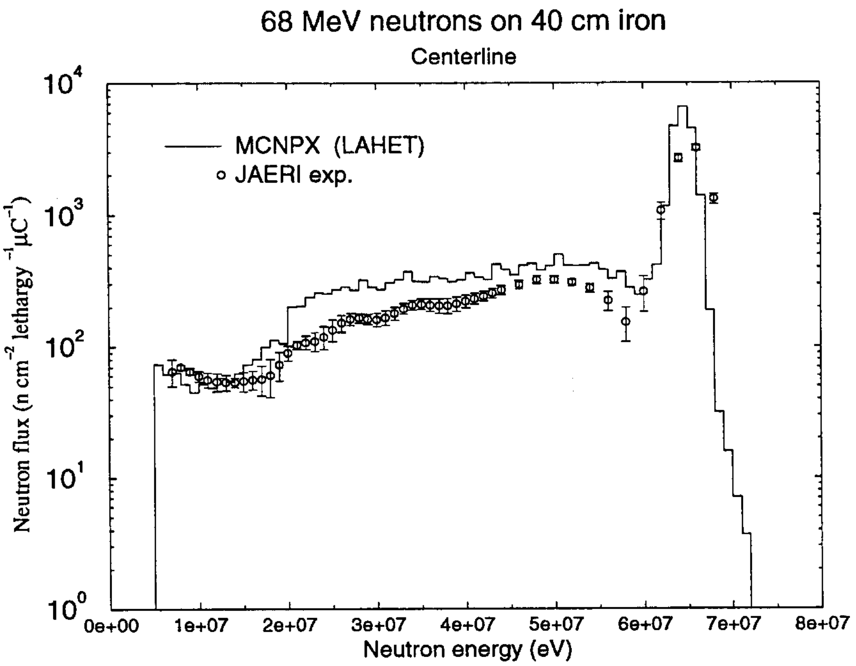

Figure 4.7 *68 MeV neutrons on 40 cm of iron, detector at centerline: Comparison between experimental data and MCNPX + LAHET above 20 MeV.*

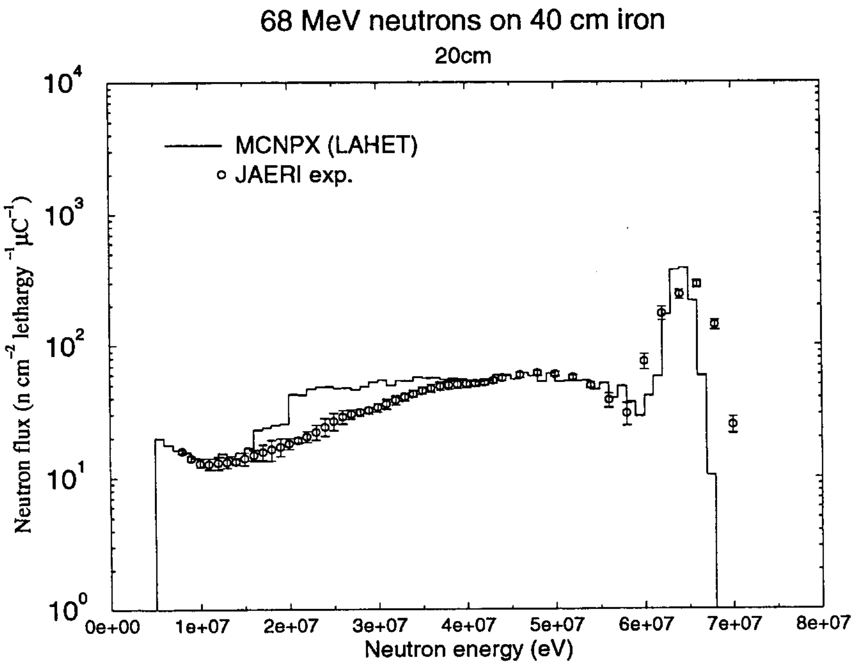

Figure 4.8 *68 MeV neutrons on 40 cm of iron, detector at 20 cm: Comparison between experimental data and MCNPX + LAHET above 20 MeV.*

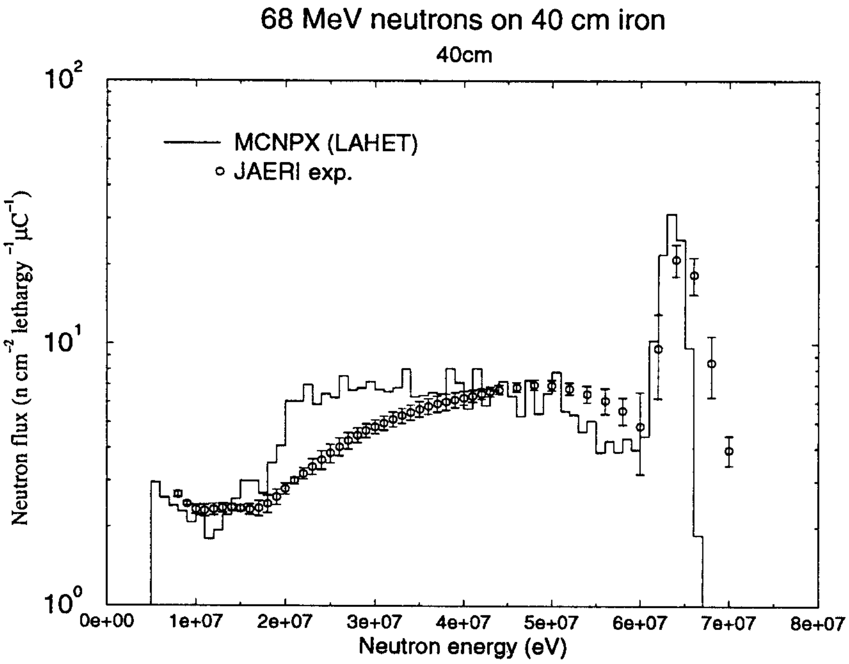

Figure 4.9 *68 MeV neutrons on 40 cm of iron, detector at 40 cm: Comparison between experimental data and MCNPX + LAHET above 20 MeV.*

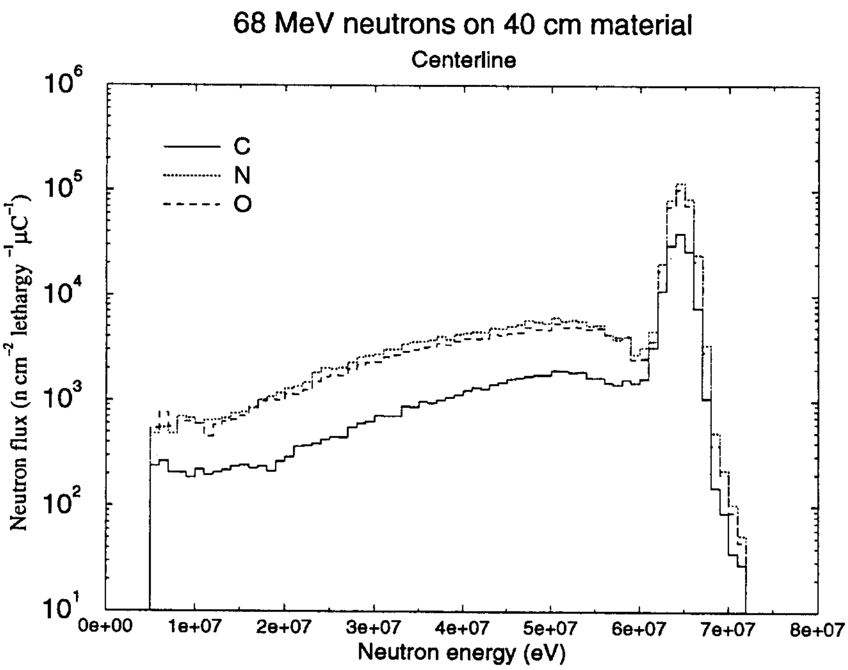

Figure 4.10 *68 MeV neutrons on 40 cm of carbon, nitrogen and oxygen, detector at centerline: Calculated result of MCNPX + LA150 datalibraries.*

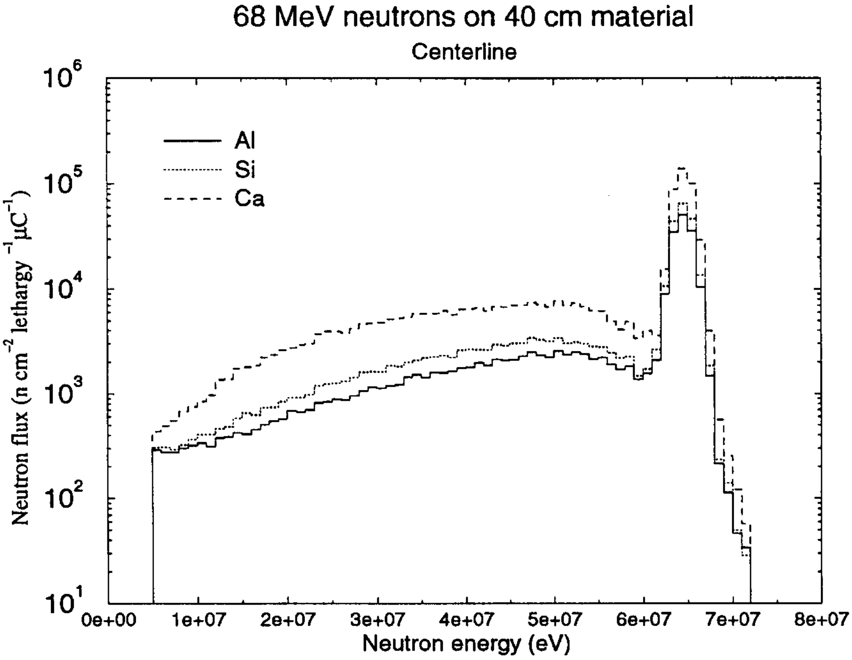

Figure 4.11 *68 MeV neutrons on 40 cm of aluminum, silicon and calcium, detector at centerline: Calculated result of MCNPX + LA150 datalibraries.*

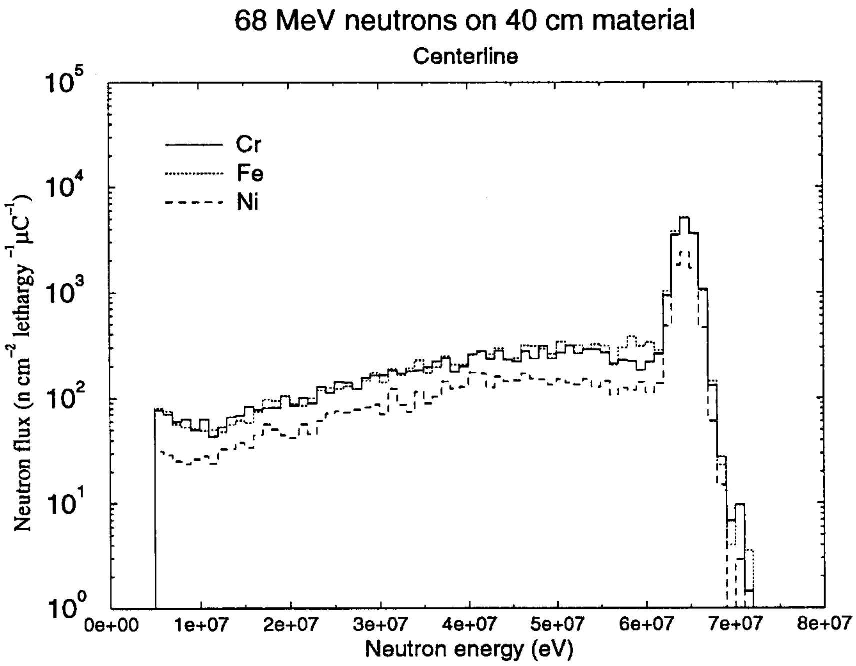

Figure 4.12 *68 MeV neutrons on 40 cm of chromium, iron and nickel, detector at centerline: Calculated result of MCNPX + LA150 datalibraries.*

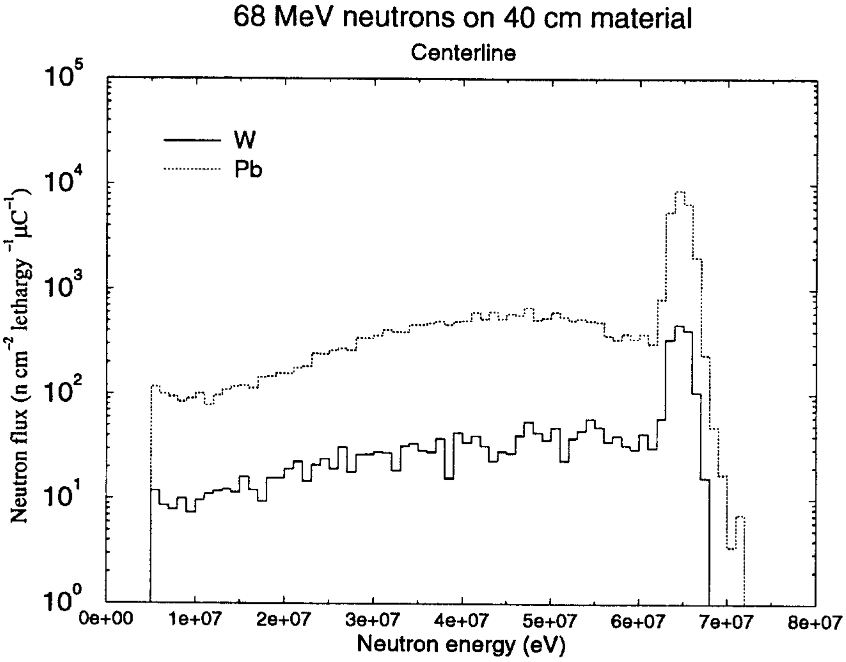

Figure 4.13 *68 MeV neutrons on 40 cm of tungsten and lead, detector at centerline: Calculated result of MCNPX + LA150 datalibraries.*

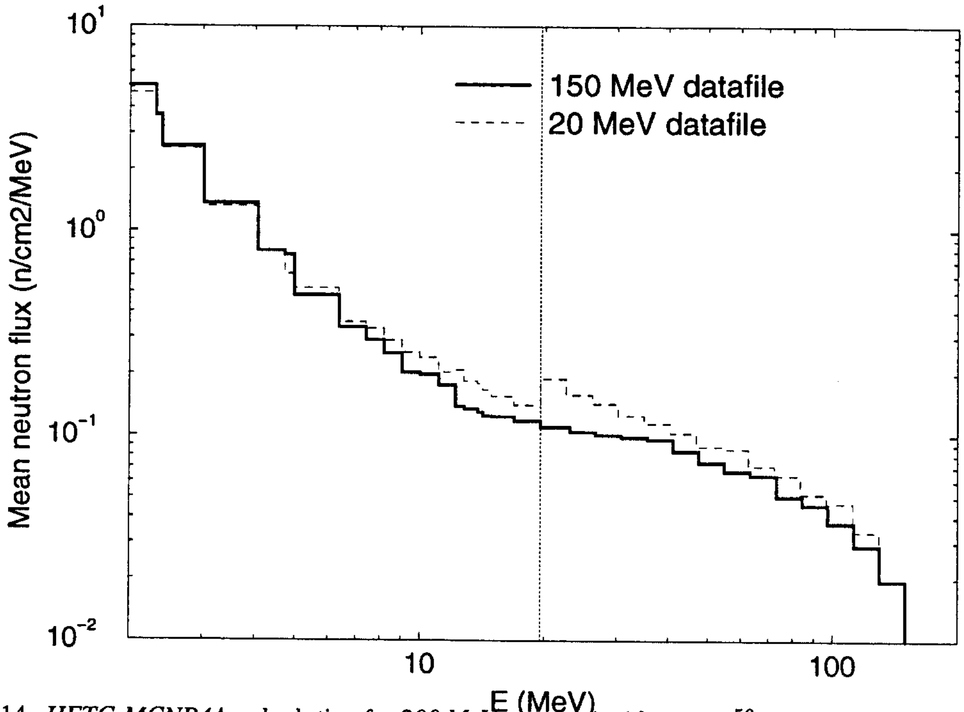

Figure 4.14 *HETC-MCNP4A calculation for 200 MeV protons incident on a ^{58}Ni cylinder with the neutron data file cutoff at 20 vs. 150 MeV. The cylinder is 50 cm long and has a radius of 20 cm. The mean neutron flux is calculated between 10 and 20 cm.*

5. Conclusions

In line with the "Phase 1" review of ENDF/B-VI, we have checked that the LA150 data show a smooth behaviour, where this is expected, by means of cross section plots. The comparison of the contents of the datafiles with experimental data reveals that the datafiles seem to be superior than anything else existing at the moment (e.g. the intranuclear cascade codes), at least consistently over such a large range of mass, energy and reaction channels. The checking codes do not complain about the contents of the files above 20 MeV, and the files can be processed by NJOY into MCNP-libraries.

The quality of several of the libraries is tightly connected with the quality of the nuclear model codes GNASH and ALICE, which are known to perform better or at least as good as its competitors [6]. In other words, they are relative safe tools when so little experimental data is available as in the intermediate energy region. It should however be mentioned, and the authors of the various libraries are aware of that, that still a lot can be gained by improveing nuclear models, of which the optical model, level density and pre-equilibrium models seem to be the most crucial. To this end, a new WPEC subgroup on nuclear model codes will be formed. Hence, the present intermediate energy libraries represent a challenge to other methods that claim to do even better in the future.

Within SG14, the LA150 and NRG/BRC data files have been tested, with the transport code MCNPX, against an iron benchmark experiment. A similar validation has been performed by others, simultaneously. For nuclear applications with nucleon energies below 150 MeV, the calculations with neutron datafiles suggest a drastic improvement of the description of macroscopic experiments, when compared with the intranuclear cascade code LAHET. This confirms the findings that where reported in [1]. For this simple benchmark experiment, there seems to be no clear quality argument in favor of either the LA150 or the NRG/BRC neutron datafiles for iron. Some discontinuities can still be observed at energies around 20 MeV, although they are no longer as big as in the LAHET + 20 MeV datafile calculations. This suggests that for a continuous description the data below and above 20 MeV should preferably be re-evaluated in one and the same working process. Also, the findings by Konno et al mentioned in the previous section need to be taken into account. Finally, we have checked that the other materials present in the LA150 data library show no strange irregularities that result from the extension to 150 MeV. For several of the data files of Table 2.1 this still needs to be done. The conclusions of SG14 is, however, that there should in principle be no problem to achieve this, provided the format procedures of the LA150 and NRG/BRC libraries are followed.

References

[1] M.B. Chadwick, P.G. Young, S. Chiba, S.C. Frankle, G.M. Hale, G. Hughes, A.J. Koning, R.C. Little, R.E. MacFarlane, R.E. Prael, L.S. Waters, "Cross Section Evaluations to 150 MeV for Accelerator-Driven Systems and Implementation in MCNPX", Nucl. Sci. Eng. 131 (1999) 293.

[2] A.J. Koning, J.-P. Delaroche and O. Bersillon, "Nuclear data for Accelerator-Driven Systems: Nuclear models, Experiments and Data libraries", Nucl. Instr. and Methods A414, 49 (1998).

[3] T. Fukahori,"Present status of JENDL High Energy File Project", JAERI unpublished (1998).

[4] U. Fischer,"High energy neutron cross-section data for the IFMIF neutron source", NEA Data Bank JEFF doc (1997), unpublished.

[5] W. Gudowski et al."Impact of accelerator based technologies on nuclear fission safety: IABAT project" EU final report, to be published, 2000.

[6] *Proceedings of the NEA Specialist Meeting on Intermediate Energy Nuclear Data: Models and Codes*, May 30-June 1 1994, Issy-les-Moulineaux, France.

[7] M.B. Chadwick, P.G. Young and P. Moller, "LA150 Library ENDF neutron cross section benchmarks" and "LA150 Library ENDF proton cross section benchmarks", Los Alamos National Laboratory, unpublished (1998).

[8] A.J. Koning and A. Hogenbirk, *High-energy nuclear data files: From ENDF-6 to NJOY to MCNP*, NEA Data Bank Report NEA/NSC/DOC(97) 8.

[9] S.V. Fortsch et al., Phys. Rev. C43, (1991) 691.

[10] Y.-O. Lee and T. Fukahori,"Intercomparison of High Energy Files (Neutron induced from 20 to 150 MeV)" JAERI unpublished (1999).

[11] Y. Nakashima et al., Nuc. Sci. Eng. 124, 243 (1996).

[12] Y. Nakane et al., "Neutron transmission benchmark problems for iron and concrete shields in low, intermediate and high energy proton accelerator facilities", JAERI report JAERI-Data/Code 96-029 (1996).

[13] Y. Nakane et al., "Intercomparison of neutron transmission benchmark analyses for iron and concrete shields in low, intermediate and high energy proton accelerator facilities", OECD proceedings *SATIF-3 Shielding aspects if accelerators, targets and irradiation facilities*, NEA Data Bank (1996).

[14] C. Konno et al.,"Analyses of the TIARA experiments using the LA150 cross section data library", JEF-DOC-808, (1999).

[15] C. Konno et al.,"DORT Analysis of Iron and Concrete shielding Experiments at JAERI/TIARA", JAERI conference, JAERI-99-002 (1999).

[16] C. Konno et al.,"Analysis of Iron and Concrete shielding Experiments for 43 and 68 MeV p-Li7 neutrons with LA150", ICRS-9 proceedings (1999).

[17] U. Fischer,"First results of benchmark calculations for intermediate energy ^{56}Fe cross section data" NEA Data Bank JEF/doc-721 (1997), unpublished.

[18] F. Maekawa and M. Wada,"Results of benchmark test with MCNP code", JAERI-conf 1999, unpublished.

[19] O. Bersillon et al.,"TIERCE: A code system for particles and radiation transport in thick targets", *Proceedings of International Conference on Nuclear Data for Science and Technology*, May 19-24 1997, Trieste, Italy, (1997), 257.