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Evaluations of the fast neutron cross sections of 52Cr and 56Fe including complete covariance information

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Abstract

A new evaluation of all important neutron cross sections of ^{52}Cr was performed in the neutron energy range 0.637 – 20 MeV, that is for the whole energy range above the resonance region. The evaluation combines the results of nuclear model calculations and the complete existing experimental data base in order to obtain the most accurate description of the cross sections possible within our present knowledge. The evaluation was performed in the following way: The cross sections from the EFF – 2 file (results of model calculations) and their estimated covariances are used as prior information which is successively improved by adding experimental data and applying Bayes' theorem to obtain the posterior information. For this process the code GLUCS was used. As the results we obtained evaluated cross sections and their covariances for a chosen set of 15 independent cross sections. A final coupled set of evaluated cross sections and covariances was obtained after imposing of the consistency conditions between partials and totals and a last GLUCS run with the experimental data for "redundant" cross sections. In addition the ^{56}Fe evaluation performed in 1992 by the same method was updated by adding the results of a number of important accurate new measurements. In this way the uncertainties for a number of important cross sections like (n,α) could be reduced considerably compared to the already rather accurate 1992 evaluation. The results of our new evaluations agree with ENDF/B–VI and EFF – 2 within the uncertainties of these evaluations.

1. Introduction

Two years ago a new evaluation of all important neutron cross sections for ^{56}Fe has been published by some of the authors of (*Vonach 92, Pronyaev 92*). In this work it has been demonstrated that evaluated cross sections of much better quality can be obtained if the results of nuclear model calculations are combined with the complete experimental data base using quantitative statistical methods based on Bayes' theorem. Evaluated neutron cross sections of this quality are needed especially for the design of the next–generation fusion reactors (*Dänner 90*). For this purpose, however, evaluated cross sections of similar quality are also required for Cr, Ni, the other main components of stainless steel, as this material is to be used as the main shielding material for protection of the superconducting coils. For this reason we are extending our evaluation program to the main isotopes of these materials. As a first step in this program this report gives the results of a new evaluation for ^{52}Cr, the main isotope of chromium.

In addition we also present an updated version of our 1992 evaluation for ^{56}Fe. The revision of this evaluation after a relatively short time was done for the following reasons:

1) A number of important precise new measurements for several important cross sections have become available within the first half of this year.

2) In course of our work on ^{52}Cr we became aware of the importance of sample–thickness effects on total cross section measurements in the region of strongly fluctuating cross sections ($E_n \approx 1 - 4$ MeV). The correction which amounts up to several percent in the important energy range 1 – 2 MeV had not been used in our 1992 iron evaluation. Therefore the data base for total cross sections of ^{56}Fe had to be corrected for this effect.

3) In course of our ^{52}Cr evaluation we decided to include also (n,d) in order to obtain a more complete evaluation. For consistency it is desirable to have this complete new evaluation also for ^{56}Fe, which could be achieved with little effort within the update necessary for reasons one and two.

2. General evaluation procedure

The general principle of our evaluation is essentially the same as used in (*Vonach 92*). For better understanding of this report we will nevertheless give a short description of this procedure; it is shown schematically in Fig. 1 and 2. As the starting point we use the EFF – 2 evaluation (*Uhl 91*) and its covariances (*Vonach 91*) with some modifications as discussed after in section 3; this constitutes our prior knowledge of the neutron cross sections of ^{56}Fe and ^{52}Cr. For each type of cross section this prior is represented by a cross section vector and its covariance matrix. For some rare reactions not contained in EFF – 2 we used ENDF/B–VI (see section 3). Then Bayes' theorem is used to add successively the experimental data for the various ^{52}Cr and ^{56}Fe cross sections to the respective prior. This is done in the following way: If the data are described by a vector R with the covariance matrix V, application of Bayes' theorem results in the following relations for the improved cross sections T' and the covariances M'

$$T' = T + MG^{+} (GMG^{+} + V)^{-1} (R - R_T) \quad (1)$$
$$M' = M - MG^{+} (GMG^{+} + V)^{-1} GM, \quad (2)$$

where R_T presents the prior value interpolated at the point where R is given, G is the sensitivity matrix of the new experimental data relative to the prior data with the matrix elements $g_{ij} = \delta R_i/\delta T_j$, and the upscript (+) means transpose and (–1) inverse operation. One of the most important conditions for obtaining these formulae is an absence of correlations between the data vectors T and R. This condition is fulfilled as T was derived from nuclear model calculations and R are results of measurements.

From this procedure (depicted at the left side of Figure 1) we get a set of improved cross sections with much reduced uncertainties compared to the prior EFF – 2 values. Cross sections for which no experimental data exist (e.g. $\sigma_{n,np}$, $\sigma_{n,n\ cont.}$) remain unchanged at this step. Due to the independent adjustment of the individual cross sections the internal consistency (e.g. between σ_{non} and the sum of all partial cross sections) gets lost to some degree. Therefore in a final step (see right side of Figure 1) this consistency, that is the physical relation between the different cross sections, is restored by a least – squares adjustment which also further improves the overall accuracy of the evaluation. For this purpose a set of independent cross sections (see Figure 1) is selected as the new prior whereas the remaining redundant cross sections (which can be expressed as linear functions of the basic cross sections) are used as "data" for application of the equations 1 and 2.

Thus the evaluations proceed in the following steps:

1) Establishment of the prior data for all cross sections of interest.
2) Establishment of the experimental data base.
3) Calculation of the improved cross sections T' and covariances M' for all important cross sections for which data are available.
4) Restoring of the internal consistency of the evaluation by a constrained least - squares adjustment of the results obtained at step 3. This leads to a final result of the evaluation in form of a cross section vector T' containing a complete set of independent cross sections and one large covariance matrix M' which can be subdivided into covariance matrices for the individual cross sections and covariance matrices between different cross section types (interreaction covariance matrices).

Technically this procedure is performed by means of the code GLUCS (*Hetrick 80*) which implements Equ. (1) and (2) and provides output on T' and M' directly in ENDF/B format. As modified recently (*Tagesen 94*) it can also be used for the constrained least squares adjustment of step 4 of our evaluation procedure.

3. Establishment of the prior information for all cross sections of interest

We decided to use the EFF – 2 evaluation as the basis for the prior (T,M) in this evaluation because it provides a complete description of the ^{52}Cr and ^{56}Fe cross sections, has sufficiently detailed covariance information and is essentially uncorrelated with the experimental data to be added. In detail, however, some modifications had to be made. Therefore, in the following a brief description of the priors actually used is given:

<u>A: Cross sections</u>

1) For the cross sections σ_{inel}, $\sigma_{n,p}$, $\sigma_{n,np}$, $\sigma_{n,2n}$, $\sigma_{n,n\alpha}$ and $\sigma_{n,\alpha}$ the cross sections from EFF – 2 were used as prior values without any changes.
2) The total cross section of iron and chromium is covered by accurate measurements over the whole energy range of this evaluation (0.85 - 20 MeV for ^{56}Fe and 0.637 - 20 MeV for ^{52}Cr). Therefore this cross section was evaluated entirely from the experimental data without any prior from model calculations.
3) Cross sections for the rare reaction (n,d) were taken from ENDF/B–VI as it is not given in EFF – 2.
4) In EFF – 2 inelastic cross sections are given separately for 33 levels and the continuum in case of ^{56}Fe and for 16 levels and the continuum in case of ^{52}Cr. In this evaluation it was not possible to individually consider the cross sections for all these existing levels. Therefore in both cases the information on inelastic scattering to discrete levels was collapsed into six partial cross sections describing either excitation of

individual levels like $\sigma_{n,n1}$ or to groups of levels (see section 4.2.3.). Values for these partial cross sections were obtained from EFF – 2 either directly or by summing over all levels in the selected groups.

B: Covariances

1) Uncertainties (standard deviations):

Relative uncertainties as a function of neutron energy were taken from the EFF – 2 covariance estimates (*Vonach 91*) for σ_{inel}, $\sigma_{n,p}$, $\sigma_{n,\alpha}$, $\sigma_{n,np}$, $\sigma_{n,2n}$ and $\sigma_{n,n\ cont}$ (see Figs. 47 and 48 of *Vonach 91*). For inelastic scattering to discrete levels EFF – 2 gives only covariances for the sum of all discrete cross sections, therefore uncertainties for the cross sections for excitation of discrete levels and the cross sections for the selected groups of discrete levels were estimated from the differences of these cross sections between the evaluations EFF – 2, ENDF/B–VI, JENDL–3 and BROND using the procedures developed in *Vonach 91*. The covariances for the (n,d),(n,t) and (n,^{3}He) cross sections were taken from ENDF/B–VI like the cross sections themselves.

2) Energy grid of the covariance matrices:

In EFF – 2 the energy range of the evaluations had been divided into intervals for the representation of the covariance matrices resulting in energy intervals of 0.5 MeV and 1 MeV within which cross sections are fully correlated. In the lower energy range of our evaluation these intervals appeared too large for a detailed description of the excitation function. Therefore a finer energy grid (40 intervals) was adopted for this evaluation. Energy bins of 0.2 MeV were chosen in the energy range up to 3.0 MeV, 0.5 MeV in the energy range 3.0 – 15.0 MeV and 1.0 MeV above 15 MeV (see e.g. Table 9). This structure of the covariance matrices was used for all cross sections.

3) For EFF – 2 a Gaussian type of correlations with a constant width (FWHM) of 4 MeV, independent of neutron energy, was assumed for all cross sections in order to describe the (positive) correlations between the cross section uncertainties at different neutron energies E_1 and E_2 (see discussion on page 6 in *Vonach 91*). Again especially in the low energy range this correlation width appeared to be too large resulting in very "stiff" excitation functions which cannot be easily adjusted to experimental data of a slightly different shape of the excitation function. Thus as a somewhat more realistic approximation in this evaluation we used a Gaussian – type correlation function with variable width (the FWHM increasing linearly from 1 at 1 MeV to 4 at 20 MeV) for generating the off–diagonal elements of the covariances of our priors. Correlation coefficients between cross section uncertainties at the energies E_1 and E_2 were calculated according to the relation

$$\mathrm{cov}(\sigma_1\sigma_2) = \mathrm{sqrt}[\mathrm{Var}(\sigma_1)\mathrm{Var}(\sigma_2)] * \exp[-((E_1-E_2)^2/\Gamma_{12}^2) * \mathrm{In}2]. \qquad (3)$$

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4. Cross section evaluation for ^{52}Cr

4.1. Establishment of the experimental data base including construction of covariance matrices for all data sets

We used the experimental data compiled in EXFOR (*Lemmel 86, McLane 88*) and supplemented them by very recent ones which were mostly obtained directly from the authors. In addition to measurements on ^{52}Cr we also used measurements on natural chromium for such cross sections for which the difference between ^{52}Cr and ^{nat}Cr is known to be small. Additionally, in order to widen our data base also some more complex cross sections like the γ – production cross section for the first 2^+ level were included in our data base if good measurements existed and accurate conversion procedures to basic cross sections, e.g. σ_{inel}, could be developed. Differential elastic and inelastic scattering cross sections measured over a sufficient angular range were used to derive the total elastic and inelastic scattering cross sections by means of fits with Legendre polynomials in those cases where the integrations had not been performed by the authors.

All data sets were critically reviewed; obviously wrong data were rejected. The accepted data were renormalized if necessary with regard to the standard cross sections or decay data used. In some cases renormalizations were also applied if comparisons of a data set with other data consistently indicated the need for such renormalizations.

For the construction of the covariance matrices of the experimental data sets it is necessary to have detailed information on all uncertainty components of the measurements and the correlation of each component within the data set. As this information is not given for most of the experiments various approximations had to be used.

For σ_{tot}, σ_{non}, σ_{el}, and all inelastic cross sections, where the uncertainty information is rather incomplete in many cases, the following procedure was adopted:

We assumed that the covariance matrix of total uncertainties can be split into three matrices of partial uncertainties:

1) a diagonal covariance matrix of partial uncertainties describing short–energy–range (SER) correlation properties such as statistical uncertainties due to a finite number of counts per channel;

2) a covariance matrix of partial uncertainties connected with properties that give rise to medium–energy–range (MER) correlations, such as uncertainties due to the correction for the dead time and to the determination of the detector efficiency, the

effect/background separation, multiple scattering and scattering at the collimator, the spectrometer resolution function and neutron source properties. For this covariance matrix the correlations between the uncertainties for different energy groups are described by a linear model of correlation propagation with a certain correlation energy Ec (typical 2 MeV) within which the correlation decreases linearly from 100% to zero.
3) a constant covariance matrix of partial uncertainties connected with properties which induce large–energy–range (LER) correlations, such as systematical uncertainties due to any normalization of the cross sections in order to get absolute values, to the determination of the number of nuclei in a sample, to geometrical sizes and distances and to sample self–absorption properties for the non–resonance energy region. This means we assume complete correlation over all energy groups for these long–range uncertainty components.

The magnitudes of the described three components were chosen according to the uncertainty information given by the authors; in the assessment of the medium–energy–range correlations (both magnitude of MER uncertainties and correlation energy Ec) also the deviations between the different data sets were taken into account as discussed more extensively in section 5.1.

For the (n,2n), (n,p) and (n,α) cross sections where on average the existing uncertainty information is somewhat more detailed, the covariance matrices were constructed more rigorously by adding up the contributions from each uncertainty component using an estimated degree of correlation for each component. Obviously missing uncertainty components were estimated and also added in some cases as explained in the sections on these reactions.

All steps for deriving the experimental data base according to the procedures outlined here are described comprehensively in section 4.2., where the evaluation of the different types of cross sections is treated in detail. The cross section values and their covariances derived in this way cannot be given in this report, they are, however, available on request at our institute.

4.2. Evaluation of the cross sections for individual reactions

4.2.1. General considerations

As discussed in Section 2 (see Fig. 1) separate improved evaluations were produced for a number of basic independent cross sections by adding the existing experimental data base to the corresponding prior information from EFF – 2 as the first step within this evaluation. The total cross section σ_{tot} and a complete set of partial non–elastic reaction cross sections (see Fig. 1) were selected as our basic cross sections. These individual evaluations are briefly described in the following subsections.

4.2.2. Total cross sections

14 experimental data sets were taken into account for the energy higher than the resolved resonance region in the ^{52}Cr evaluated data file from the EFF – 2 library. The high resolution data were averaged in 41 energy groups having a width between 0.163 MeV and 1.0 MeV in the energy range from 0.637 MeV to 20.0 MeV. All cross sections were reduced to the zero sample thickness where it was needed based on the data given in (X4 = 10342, *Perey 73*). The group averaged data show an energy structure which is not in the ^{52}Cr EFF – 2 file, because the evaluation is based on the results of optical model calculations which are not able to reproduce this structure. Due to this deficiency of the EFF – 2 file, the experimental data (20012 *Cierjacks 68*) covering the whole energy range under investigation with assigned uncertainties and correlation matrix were used as prior data for applying the Bayesian procedure to the evaluation.
Each experimental data set was analyzed and total uncertainties were obtained as sum of 3 components, namely presenting short (SER), medium (MER) and large energy range (LER) correlations. For MER correlations we have used the linear model of correlations propagation with a width 2 MeV. For evaluation of the MER variances the deviation between given data set and general average obtained by simple averaging of all experimental data on the width of MER correlations (2 MeV in our case) was used.
A summary of the experimental data base with evaluated partial uncertainties is given in Table 1. Most total cross section experimental data are for natural chromium. Only one data set is available for ^{52}Cr (see Table 1). We have decided to use the total cross section experimental data for the natural mixture of isotopes for the evaluation of ^{52}Cr total cross section for the following reasons. First of all they do not differ more than 1%

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for these group averages. Secondly, in most applications the total cross section is used only for the natural mixture of isotopes. The total cross section for the minor isotopes is not so well investigated as for the main or the natural mixture. Therefore for most applications it is better to use for all isotopes the total cross section for the natural mixture of isotopes.

The evaluation was done by chosing the data set 1 (*Cierjacks 68*) which covers the whole energy range as our prior and adding the other data consecutively in the order given in Table 1 by means of the mentioned computer code GLUCS. In this way the consistency of the various data sets is checked in detail, as we get a value of χ^2 per degree of freedom for each data set added to the evaluation. These χ^2 values are also given in Table 1.

The average chi–square per degree of freedom for all data sets is equal to 0.7.

The standard deviations for the evaluated data are changing from 0.4% at 4 MeV up to 1.2% at 20 MeV. The evaluated total cross section has some structure and differs from the EFF – 2 total cross section up to 10% in some energy groups. The evaluated correlation matrix is positive definite and has no visible peculiarities.

4.2.3. Partial inelastic cross sections

The EFF – 2 file contains evaluated cross sections for 16 levels in the excitation energy range up to 4.563 MeV. This level scheme is rather well established. For this evaluation only the cross sections for excitation of the first and second excited level were treated separately whereas the cross sections for excitation of higher levels were lumped into three groups as a compromise between the desire for a detailed description and the need to keep the number of basic cross sections within reasonable limits. The choice of the groups was also influenced by the quality of the available data which does not allow to resolve of the individual levels at high excitation energies.

A special case is formed by the 3^- level at E_x = 4.563 MeV (level 16) which (as an octopole vibration) is strongly excited in inelastic scattering at higher energies and therefore also well resolved in experiments. There the inelastic scattering to this level was also treated separately.

Thus the following basic cross sections were chosen:

1. MT = 51, E_{lev} = 1.434 MeV
2. MT = 52, E_{lev} = 2.370 MeV
3. MT = 53 – 57, E_{lev} = 2.647 – 3.162 MeV
4. MT = 58 – 61, E_{lev} = 3.415 – 3.772 MeV

5. MT = 62 – 65, E_{lev} = 3.946 – 4.038 MeV
6. MT = 66, E_{lev} = 4.563 MeV
7. MT = 91, $E_{lev} \geq$ 4.582 MeV

All experimental data for these cross sections were analyzed and corrected where it was needed from the natural element to ^{52}Cr isotope content. The angular differential data were integrated using the code GPOLFIT (*Pavlik 90*).

The experimental data for excitation of the first and second level (MT 51 and 52) and for the group of levels 3 – 7 are summarized in Tables 2 – 4.

For MT 852 amd 853 (excitation of level 8 – 11 and 12 – 15) and also for the continuum cross section (MT 91) no measurements exist. For excitation of level 16 (MT 66) one measurement (*Stelson 65*) was found.

Starting from EFF – 2 as prior, improved evaluations were obtained by successive addition of the data by means of the code GLUCS as described before for MT 51, MT 52, MT 851 and MT 66. Again the χ^2 values are listed in the corresponding tables. Average χ^2 values per degree of freedom of .76, .63 and .72 were found for the evaluation of MT 51, 52 and 851 respectively, confirming good consistency both between the different experimental data and the EFF – 2 evaluation chosen as prior.

For the level groups 8 – 11 and 12 – 15 (MT 852 and 853) and for the scattering cross section to the continuum no improvement of the prior was possible due to the lack of data.

4.2.4. (n,2n) cross sections

A careful evaluation of this cross section has been performed recently (*Wagner 90*) within the IRDF90 (International Reactor Dosimetry File) project which is still valid as no new data have been reported. Therefore no new evaluation of this cross section was performed. Instead the results of Wagner (cross sections and covariance matrix) were transformed to the energy grid of the present evaluation by means of a suitable interpolation procedure and used as prior for our evaluation (see Fig. 1).

4.2.5. (n,p) cross sections

A summary of the 22 data sets accepted for this evaluation is given in Table 5. They can be separated into 4 groups:

- the only experiment in the energy range from threshold to 9 MeV provided by *Smith 80*;
- recent accurate cross section measurements carried out by *Ikeda 88*, *Kawade 90* and *Viennot 91* in the neutron energy range 13.3 to 15 MeV;
- many single point measurements (mainly obsolete and poorly documented) in the range from 14 to 15 MeV;
- shape cross section measurements by *Kern 59*, *Clator 69* and *Ghorai 87* above 12 MeV.

The experimental data were renormalized to new standard cross sections and decay constants where necessary (see Table 6). The effect of competing reactions was taken into account, if necessary. Because the evaluated cross sections in the energy region 13 to 15 MeV are determined by precision cross section measurements (*Ikeda 88*, *Kawade 90* and *Viennot 91*), the procedure of their renormalization requires detailed description. All these experimental data were measured by activation technique relative to the ^{27}Al(n,p) reaction cross section. At present there are two reliable ^{27}Al(n,p) reaction cross section evaluations, ENDF/B–VI (*Young 73*) and (*Ryves 88*). We have chosen the ENDF/B–VI evaluation for two reasons. First, this evaluation covers the whole energy range of interest, while the other ranges from 14 to 15 MeV. Second, we have tested three variants of renormalization (to the ^{27}Al(n,p) reaction cross section evaluation of ENDF/B–VI and ^{27}Al(n,α) standard reaction cross section) for Ikeda and Kawade data. The results of the first renormalization lie between the two others. Because the uncertainties of the ^{27}Al(n,p) reaction cross section from ENDF/B–VI are evidently overestimated, we have used the maximum deviation between two evaluations (ENDF/B–VI and *Ryves*) in the energy range from 14 to 15 MeV instead of them.

The data of the old single point measurements (carried out with the use of NaI low resolution detectors and direct particle registration for neutron flux monitoring) are rather scattered. Therefore an uncertainty of 20% was assigned after analysis to all these data.

The results of comprehensive shape cross section measurements carried out by *Kern* and *Clator* deviate from *Ikeda 90*, *Kawade 90* and *Viennot 91* data by 40% on the average. Accordingly the results of these shape cross section measurements were renormalized to the weighted average of the last three data sets at the energy point 14.74 MeV.

4.2.6. (n,α) cross sections

Only one data point (*Grimes 79*) exists at E_n = 14. MeV. It was added to the EFF – 2 prior resulting in a slight reduction of the uncertainty around 14.8 MeV.

4.2.7. (n,np), (n,nα), (n,d) and (n,γ) cross sections

No data exist for any of these cross sections, thus no improvement of the priors was possible in the first evaluation step.

4.3. Data base for redundant cross sections

Apart from the discussed data for our basic set of independent cross sections, there exists a large body of rather accurate experimental data of so-called redundant cross sections. These cross sections (σ_{el}, σ_{inel}, σ_{non} and σ_{p-prod}) are related to our basic cross sections by simple linear relations:

$$\sigma_{inel} = \sigma_{n,n1} + \sigma_{n,n2} + \sigma_{n,n3-7} + \sigma_{n,n8-11} + \sigma_{n,n12-15} + \sigma_{n,n16} + \sigma_{n,ncont} \quad (4)$$

$$\sigma_{non} = \sigma_{inel} + \sigma_{n,2n} + \sigma_{n,p} + \sigma_{n,np} + \sigma_{n,\alpha} + \sigma_{n,n\alpha} + \sigma_{n,d} + \sigma_{n,\gamma} \quad (5)$$

$$\sigma_{el} = \sigma_{tot} - \sigma_{non} \quad (6)$$

$$\sigma_{p-prod} = \sigma_{n,p} + \sigma_{n,np} \quad (7)$$

As these data can be used for further improvement of our basic cross sections (see next section) we give in the following a short overview on the existing data base for these reactions.

A summary of the existing data on σ_{inel}, the total inelastic cross sections, is given in Table 5. These data present the results of direct integration of the inelastic neutron scattering spectra or results of gamma-line production cross section measurements for the transition between first excited level (E_{lev} = 1.434 MeV, $I^{\pi} = 2^+$) and ground state. Due to the specific property of the gamma-transition scheme in vibrational nuclei (as even-even iron, chromium and nickel isotopes) more than 90% of all gamma-transitions are passing through the low-lying 2^+ level depending from neutron energy. The evaluation for ^{52}Cr has shown that for energy higher than 3.5 MeV probably 95% of all decays in average end up with E_γ = 1.434 MeV transition. A similar conclusion was obtained for the ^{56}Fe nucleus (*Vonach 92*). Using this correction, the 1.434 MeV gamma-line production cross sections were reduced to the total inelastic scattering cross section. The important results of *Larson 85* not yet reported in EXFOR were obtained directly from the author.

The data for σ_{non}, the total nonelastic cross sections, are given in Table 7. It is to be noted that this cross section is very accurately known at E_n = 14 MeV, which demonstrates the importance of using all information (from both basic and redundant cross sections) for our optimum evaluation.

Finally the data on elastic scattering are summarized in Table 8.

Only one measurement (*Grimes 79*) at E_n = 14.8 MeV exists for the total proton production cross sections.

4.4. Consistent joint evaluation of all cross sections

As the final step of the evaluation (see right side of Figure 1) an improved evaluation using the information contained in both our basic and redundant cross sections was obtained in the following way: The redundant cross sections (see section 4.2.) were added as "data" of sums or differences of basic cross sections according to equ. 4 – 7 again using the code GLUCS based on equ. 1 and 2 (see section 2). The posterior derived in this way not only strictly fulfill the consistency relations (equ. 4 – 7) but are also considerably improved in quality as many of the redundant cross sections (e.g. σ_{non} or σ_{inel}) are known rather accurately and this accuracy is in part transferred to the basic cross sections by means of the applied constrained least squares fit. Technically all accepted redundant cross sections (see section 4.3.) of all types were added as one large data vector to the prior consisting of the coupled set of all basic cross sections in one GLUCS run.

Because of the conditions (4 – 7) and the consideration of all basic cross sections as one coupled set the resulting correlation matrix now includes parts which describe correlations between different energy intervals of different cross sections. In most cases these correlations are small (< 10%), in some cases however e.g. between different partial inelastic cross sections they are important and have to be taken into account.

4.5. Results of the evaluation

The main result of this evaluation is a complete but non–redundant set of cross sections (σ_{tot}, $\sigma_{n,n1}$, $\sigma_{n,n2}$, $\sigma_{n,n4-7}$, $\sigma_{n,n8-11}$, $\sigma_{n,n12-15}$, $\sigma_{n,n16}$, $\sigma_{n,ncont}$, $\sigma_{n,p}$, $\sigma_{n,np}$, $\sigma_{n,\alpha}$, $\sigma_{n,n\alpha}$, $\sigma_{n,2n}$, $\sigma_{n,d}$ and $\sigma_{n,\gamma}$) and their covariances in the fast neutron energy range 0.63 – 20

MeV in our 41–group structure. In addition, cross sections and covariances for σ_{el}, σ_{non} and σ_{inel} were obtained by expressing these cross sections as linear functions of the basic cross sections (see equations 5 – 7). In the tables 9 – 17 the final results of this evaluation, i.e., the cross sections and their uncertainties, are listed. There is, however, some difference in the meaning of the listed cross section values between σ_{tot} and σ_{el} on the one hand and all the other cross sections. Due to the special evaluation procedure used for σ_{tot} (see section 4.2.2.) the evaluated cross sections are group cross sections averaged over the bins of our 40 resp. 41 group bin structure. As σ_{el} was essentially derived as difference between σ_{tot} and all other cross sections, also the listed σ_{el} values are essentially group–averaged cross sections. All other cross sections, however, are point cross sections, as their priors are the point cross sections from EFF–2 and also the added data are approximately point cross sections. This difference however is only of importance in the energy range below 4 MeV, for higher energies both σ_{tot} and σ_{el} are smooth functions of energy and the listed values can also be considered as point cross sections at the respective energy bin centers. In the energy region below 4 MeV the known fine structure of the total (and elastic) cross sections will have to be superimposed on our evaluated group cross sections for an accurate description of σ_{tot} in file three of our evaluated data file, while retaining our course group structure in the description of the covariances in file 33.

These results are also presented in the Figures 3 – 23. For convenience two figures are shown for each reaction for which experimental data have been included (see Fig. 1): the first figure displays the adjusted experimental data base together with the cross sections from the EFF – 2 file and its uncertainty limits, taken usually as the prior data; the second figure compares the prior EFF – 2 cross sections and the corresponding uncertainties (now shown as open circles) with the resulting excitation function from the present evaluation. For the remaining cross sections, for which no experimental data have been published, a figure is given showing the prior data and the final evaluated result for those reactions only where the evaluation had a noticeable impact on the cross sections. In these cases the improvement is entirely due to the experimental data on the redundant cross sections introduced at the last step of the evaluation. A special case is the (n,2n) cross section. As discussed before, the experimental data for this reaction have been evaluated recently (*Wagner 90*) and this evaluation has been used by us as prior instead of EFF – 2 because of its much smaller uncertainties. The improvement obtained in this way is shown in Fig. 20 which compares the EFF – 2 cross sections with the result of this evaluation (which is practically identical with the Wagner evaluation).

From these figures the progress achieved in this evaluation is immediately obvious. Our main conclusions are rather similar to those obtained in our previous evaluation for ^{56}Fe (*Vonach 92*):

1) Except for the total cross sections in the fluctuation region below 4 MeV the results of this evaluation remain within the uncertainty limits of EFF – 2 for all reaction types and energies. Thus our new more accurate evaluation confirms the validity of the uncertainty estimates for the EFF – 2 cross sections which were derived from the dispersion of recent evaluations.
2) The largest improvement in the evaluated cross sections was attained in the energy region below 3 MeV. At these low energies the theoretical description of the cross section by means of the optical model becomes rather poor so that rather large uncertainties are to be assigned to any calculated cross sections (*Vonach 91*) and experimental data are more accurate.
3) The most important improvement of our new evaluation is certainly the considerable reduction of the uncertainties for the cross sections in energy ranges where accurate measurements exist. For the most important cross section σ_{tot} the uncertainties could be reduced by more than a factor of five. Similar improvement could be obtained for $\sigma_{n,2n}$ and $\sigma_{n,p}$ over the whole energy range. Considerable improvement (by factor 2 – 3) could also be obtained for σ_{el}, σ_{non} and σ_{inel} in the interesting energy range around 14 MeV and in the low MeV range also quite important for neutron transport calculations. The Figures however also do show that the data base for ^{52}Cr is still considerably worse than that for ^{56}Fe and data are still lacking for many important cross sections over large energy ranges. Therefore – as shown in the Figures – no improvement over EFF – 2 was possible for some important cross sections like (n,α) and the most of the partial inelastic cross sections especially for higher neutron energies.

One might question the rather small uncertainties resulting from our evaluation because of possible correlations between our prior data and the added data sets. This objection, however, is not valid because the statistical weight of the priors becomes negligible if the added data are much more accurate than the prior ones, and just this situation exists in these parts of our evaluation where the uncertainties are very low.

Of course, as is the case with any evaluation of experimental data, the uncertainties of our results could be too small because of unrealistically low uncertainty estimates given for the data or because of neglecting correlations between different data sets. As discussed in the previous chapters we accounted for such effects by increasing the uncertainty components as estimated by the authors in all cases which appeared doubtful to us. Correlations between different data sets were checked and generally found to be small. Finally our uncertainty estimates are confirmed by the fact that in all evaluations of individual cross sections and in the final joint evaluation χ^2 values of about unity were obtained. According to our judgement which is also based on our previous experience with evaluations of experimental data (*Pavlik 88, Wagner 90, Vonach 91, Vonach 92*) the final uncertainties of the present evaluation are realistic effective standard deviations at the 1 σ confidence level.

In addition, a comparison of the most important cross sections with the reaction cross sections as recommended in the ENDF/B-VI evaluation is presented in the Figures 28 - 32. In general both evaluations agree within their combined uncertainty limits. On the average it appears that the uncertainties in ENDF/B-VI have been estimated somewhat too pessimistic as already observed in (*Vonach 92*) for the case of ^{56}Fe.

All correlation matrices for the uncertainties of the different reactions are positive definite. There are strong positive correlations between cross sections for neighboring energies which decrease strongly with the energy difference between the considered points and become negligible for energy differences above a few MeV as shown in Fig. 24 - 27. The detailed structure of these matrices is determined by the strength of the mainly positive correlations present in the various data sets used in the evaluation and varies considerably between different cross section types (see Fig. 24 - 27). The cross correlations between cross sections for different reactions are small for most reaction pairs.

In spite of the improvements obtained in this evaluation our results clearly show that the experimental base is still inadequate and considerable improvements are possible by new measurements using well established methods. In detail we propose the following experiments:

1) Measurement of the α-emission cross section from threshold to 14 MeV (no data at present).

2) Measurement of the (n,p) activation cross section from threshold to 14 MeV (at present there exists only one measurement).

3) Measurement of partial inelastic cross sections in the energy region from a few MeV to 14 MeV.

4) Accurate measurements of σ_{non} for a few energies below 14 MeV.

5. Update of the ^{56}Fe evaluation

5.1. Establishment of the experimental data base including construction of covariance matrices for all data sets

The experimental data base for the neutron cross sections of ^{56}Fe up to 1992 has been analyzed and described in detail in *Vonach 92*.

For this evaluation the data base was changed in two ways

a) A number of important new data sets were added.

b) The data sets for σ_{tot} of *Vonach 92* were corrected for the effect of finite sample thickness.

The new data included in this evaluation are summarized in Table 9. Although consisting mostly of still unpublished work sufficient uncertainty information was supplied by all authors to enable us to construct rather accurate covariance matrices for all data sets. The PTB data on elastic and inelastic neutron scattering and the α–production data on ^{56}Fe could be used directly as point cross sections. The α–production measurement of (*Baba 94*) performed on natural iron was converted to ^{56}Fe by means of the relation

$$\sigma_{56} = (\sigma_{nat} - 0.059\,\sigma_{54})\,/.929 \qquad (8)$$

using ENDF/B–VI cross sections for $\sigma_{n,\alpha}$ of ^{54}Fe. This relation assumes that the (n,α) cross sections of ^{57}Fe and ^{58}Fe are half of the cross sections for ^{56}Fe. Because of the low abundance of ^{57,58}Fe and the rather small uncertainties of the ^{54}Fe(n,α) cross sections (≈ 5%) the uncertainties introduced by this procedure remain small compared to the uncertainties of the σ_{nat} values. The high resolution total cross section data were preaveraged in our 40 group structure as discussed in section 4.2.2. for the evaluation of σ_{tot} for ^{52}Cr.

The most important new data set is certainly the new high–resolution total cross section measurement (*Weigmann 94*). This measurement was performed with a resolution of about 0.004 nsec/m which is more than one order of magnitude better than any previous measurement. Thus it is the first measurement which really seems to resolve the structures present in the iron total cross section below 4 MeV. It is therefore the first measurement not effected by systematic errors due to self–shielding.

For any measurement with insufficient energy resolution and finite sample thickness measured cross sections are systematically too small, as for a fluctuating cross section the average transmission is always larger than the transmission according to the average cross section because of self–shielding. Therefore all transmission measurements have to be reduced to zero thickness or by other words corrected at sample thickness. This correction depends on the resolution function of the particular experiments and can be determined either experimentally from a set of measurements with different sample thicknesses by extrapolation to zero sample thickness or calculated as:

$$\Delta\sigma = \ln(< \exp(-\sigma_{tot}(E)d) > / \exp(- < \sigma_{tot}(E)d >)) / d \qquad (9)$$

where $\Delta\sigma$ is a correction to the cross sections obtained from transmission data not reduced to zero sample thickness, d is the nuclear thickness in units of nuclei/b, $\sigma_{tot}(E)$ is a "true" cross section and averaging is carried out with a resolution function of the "thick" sample experiment. Unfortunately, the experimental data on total cross section in (*Vonach 92*) were not corrected at sample thickness because of absence of the required information at that time.

With the availability of the new high resolution data (*Weigmann 94*) it became possible to correct this deficiency of our previous evaluation and equ. 9 was used to correct all total cross section data below 5 MeV used in (*Vonach 90*) for the finite sample thickness effect. This correction was as high as 10% for some data in the low energy groups.

5.2. Evaluation of all ^{56}Fe cross sections

In principle new data can be simply added to an evaluation performed by means of GLUCS without repeating all previous evaluation steps. In case of our update of ^{56}Fe, however, in addition to adding new data sets we have to correct a number of data sets for σ_{tot} used in the old evaluation for the effect of finite sample thickness. Therefore the whole evaluation was repeated as shown in Fig.2. Thereby we used:

a) The data sets for σ_{tot} (*Vonach 92*) corrected for finite sample thickness effect

b) all other data sets of (*Vonach 92*) unchanged

c) the new data sets listed in Table 18

These data sets were combined in a two step process as shown in Fig.2. In the first step improved separate evaluations of σ_{tot}, $\sigma_{n,n1}$, $\sigma_{n,n2}$, $\sigma_{n,n3}$, $\sigma_{n,n4-7}$, $\sigma_{n,n8-14}$, $\sigma_{n,n15-32}$, $\sigma_{n,p}$, σ_{non}, $\sigma_{n,\alpha}$ and $\sigma_{n,2n}$ were created by adding the existing experimental data to our EFF – 2 prior by means of separate GLUCS calculations for each of these cross section types. In the second step our whole set of 17 basic independent cross sections (including 10 cross sections improved in the first step) is used as one new prior and the "redundant" experimental data for σ_{el}, σ_{non}, σ_{inel}, σ_{p-prod} and $\sigma_{\alpha-prod}$ are added simultaneously resulting in a new set of our 17 basic cross sections of much improved quality also for a number of cross section types for which no direct measurements exist.

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5.3. Results of the evaluation

The main result of this evaluation is a complete but non-redundant set of cross sections (σ_{tot}, $\sigma_{n,n1}$, $\sigma_{n,n2}$, $\sigma_{n,n3}$, $\sigma_{n,n4-7}$, $\sigma_{n,n8-14}$, $\sigma_{n,n15-32}$, $\sigma_{n,ncont}$, $\sigma_{n,p}$, $\sigma_{n,np}$, $\sigma_{n,\alpha}$, $\sigma_{n,n\alpha}$, $\sigma_{n,\gamma}$, $\sigma_{n,t}$, $\sigma_{n,^3He}$ and $\sigma_{n,d}$) and their covariances in the fast neutron energy range .85 – 20 MeV. In addition cross sections and covariances for σ_{el}, σ_{non} and σ_{inel} were obtained by expressing these cross sections as linear functions of the basic cross sections (see equ. 5 – 7). In tables 18 – 27 these results, i.e. the cross sections and their uncertainties are listed. There is, however, some difference in the meaning of the listed cross section values between σ_{tot} and σ_{el} on the one hand and all the other cross sections. Due to the special evaluation procedure used for σ_{tot} (see section 4.2.2.) the evaluated cross sections are group cross sections averaged over the bins of our 40 resp. 41 group bin structure. As σ_{el} was essentially derived as difference between σ_{tot} and all other cross sections, also the listed σ_{el} values are essentially group–averaged cross sections. All other cross sections, however, are point cross sections, as their priors are the point cross sections from EFF–2 and also the added data are approximately point cross sections. This difference however is only of importance in the energy range below 4 MeV, for higher energies both σ_{tot} and σ_{el} are smooth functions of energy and the listed values can also be considered as point cross sections at the respective energy bin centers. In the energy region below 4 MeV the known fine structure of the total (and elastic) cross sections will have to be superimposed on our evaluated group cross sections for an accurate description of σ_{tot} in file three of our evaluated data file, while retaining our course group structure in the description of the covariances in file 33.

Those cross sections, which have been improved by the addition of new data, that is σ_{tot}, $\sigma_{n,el}$, $\sigma_{n,n1}$, $\sigma_{n,n2}$, $\sigma_{n,n3}$, $\sigma_{n,n4-7}$, $\sigma_{n,n8-14}$, $\sigma_{n,n15-32}$, and $\sigma_{n,\alpha}$ are also shown in Fig. 33 – 50. For convenience two figures are shown for each of the reactions, the first figure displays our 1992 evaluation and the new data; the second figure compares our present result with our prior (our 1992 evaluation).

In the discussion of these results we have to deal separately with the new evalution for σ_{tot} and the rest of the evaluations.

For all cross sections except σ_{tot} the new data are in good agreement with our 1992 evaluation and thus give a further confirmation on the validity of our evaluation methodology. As the new data, especially for σ_{el} and the various partial inelastic cross sections are quite accurate, a considerable reduction of the uncertainties could be obtained as apparent from Fig. 37, 39, 41, 43, 45, 47, 49 and 51. Comparing our new evaluations with the 1992 results the biggest improvement in the quality of the evaluation was achieved for the (n,α) cross sections (see Fig. 50 and 51) due to the new measurements (*Haight 94, Baba 94*) performed within the coordinated research program of the IAEA on "Improvement of measurements of theoretical computations and evaluations of neutron–induced helium production cross sections".

The results of the re–evaluation of the total cross section require some additional comments. As seen from Fig. 35 the re–evaluated total cross section changed well beyond the limits of uncertainty of the 1992 IRK evaluation for the energy region below 3 MeV and was changed substantially for neutron energy higher than 15 MeV. Concerning the energy region below 3 MeV this is purely the result of the sample thickness correction introduced in all experimental data after the high resolution data of (*Weigmann 94*) became available that could be used for this procedure. As seen from Fig. 34 the different experimental data for this energy range are going to be very consistent after introducing the sample thickness correction. With this experience we may conclude that the evaluated uncertainties may be considered as realistic only in the limits of our (sometimes very personal) understanding of all the factors which may influence uncertainties. Due to this we are not free in the future from such revision of the evaluated cross section which may bring it outside the limits of uncertainty of the old evaluation.

A shift to higher values in the evaluated total cross section for neutron energies higher than 15 MeV (Fig. 35) occurred because of the impact of the accurate new data from (*Weigmann 94*) and because we have revised (increased) the uncertainties of the experimental data for these energies for the older experiments. The total cross section in this energy region has to be very smooth from our physical understanding and it is a reason why we have increased the uncertainty of those experimental data which have visible fluctuations.

Fig. 52 – 57 show graphical presentation of the evaluated correlation matrices for σ_{tot}, σ_{el}, σ_{non}, σ_{inel}, $\sigma_{n,2n}$ and $\sigma_{n,p}$. As seen, the correlation matrices are symmetrical, contain mainly positive correlation coefficients and have a rather developed structure which for the total cross section shows visible long energy range correlations for a neutron energy region below 10 MeV.

Finally in Fig. 58 – 61 our results are compared to ENDF/B–VI for some important cross sections. As for ^{52}Cr there is excellent agreement with ENDF/B–VI for σ_{tot}, σ_{el} and the main components of the reaction cross sections. Compared to our IRK 92 evaluation the agreement with ENDF/B–VI has improved noticeably by the revisions contained in this evaluation for both σ_{tot} and σ_{el}.

The only larger discrepancy to ENDF/B–VI exists for the (n,α) cross section (see Fig. 61), where the data base existing at the time of the ENDF/B–VI evaluation was much poorer than at present and therefore that evaluation definitely needs to be revised.

As demonstrated by the figures and tables most of the important neutron cross sections of ^{56}Fe are now known sufficiently accurate for many applications. Only extremely precise measurements or measurements specifically designed to address some still existing weak points will be able to further improve the status of the ^{56}Fe cross sections. One such weak point is still the fine structure of the σ_{inel} cross section at at low energies (threshold - 4 MeV). While the fine structure of σ_{tot} has been measured recently with very high resolution (*Weigmann 94*) no such data exist for the partial cross sections σ_{el} and σ_{inel}. This situation could be substantially improved by a new accurate high resolution measurement of σ_{inel} by means of measuring the γ-production cross section for the transition from the first excited 2^+ level to the ground state.

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Table 1: Experimental data base for the natural chromium total cross section with assigned maximal uncertanties for energy range SER, MER and LER.

EXFOR ENTRY	Reference	Number of Points	Energy Range (MeV)	SER* %	MER* %	LER* %	χ^2
20012	Cierjacks 68	41	0.637 – 20.0	0.7	3.8	1.5	-
10047 (^{52}Cr)	Foster 71	27	2.4 – 15.0	1.8	1.9	1.0	0.9
10047 (^{nat}Cr)	Foster 71	27	2.4 – 15.0	1.8	1.9	1.0	0.3
10342	Perey 73	40	0.8 – 20.0	3.2	3.0	1.0	0.8
11012	Bonner 54	12	2.4 – 7.5	2.8	2.8	1.0	2.0
11155	Bratenahl 58	5	7.0 – 14.0	1.2	2.4	1.0	0.4
12750	Guenther 82	3	3.0 – 4.5	0.2	0.1	1.0	0.3
12882	Larson 80	34	2.0 – 20.0	1.3	2.0	1.0	0.3
20168	Manero 67	4	3.5 – 5.5	0.9	2.4	1.0	1.2
30149	Tran Ung 72	1	3.1	2.2	(total)		0.1
60949	Thibault 67	1	2.7	4.0	(total)		0.0
68023	Tsukada 68	1	3.95	5.0	(total)		0.0
Evaluation	Vonach 91	1	14.0	0.6	(total)		0.4
Priv.Com.	Larson 94	41	0.637 – 20.0	0.5	1.5	1.0	0.7

* Short range (SER), medium range (MER) and long range uncertainty (LER) assigned to data set.

Table 2: Experimental data base for the inelastic scattering cross section with excitation of first level (MT=51), (* – from γ–transition measurements).

EXFOR ENTRY	Reference	Number of Points	Energy Range (MeV)	SER %	MER %	LER %	χ2
10413	Kinney 74	11	4.07 – 8.56	15.4	0.0	12.8	0.98
11396*	Cranberg 56	1	2.45	12.5	total		0.09
20788	Almen–Ramström 75	9	2.50 – 4.50	12.2	0.0	8.7	0.25
21373	Beghian 55	1	2.50	33.0	(total)		0.13
40101	Popov 71	1	4.40	9.0	(total)		0.93
10413	Kinney 74	3	6.44 – 8.04	23.0	0.0	16.0	0.34
22128	Olsson 89	1	21.6	25.0	(total)		0.28
40045	Pasechnik 69	1	2.9	16.0	(total)		0.68
40047	Degtyarev 67	5	1.80 - 3.80	17.8	0.0	13.0	1.39
40311	Sokolov 73	1	2.9	9.4	(total)		0.44
40499	Lebedev 78	1	4.7	15.0	(total)		1.28
40531	Korzh 75	3	2.00 – 3.00	3.5	0.0	2.3	2.20
40619	Korzh 78	3	5.00 – 7.00	4.0	(total)		0.28
22121	Schrederer 88	1	7.75	10.0	(total)		0.27
Evaluation	Vonach 91	1	14.0	15.0	(total)		0.16

Table 3: Experimental data base for the inelastic scattering cross section with excitation of second level (MT=52), (* – from γ–transition measurements).

EXFOR ENTRY	Reference	Number of Points	Energy Range (MeV)	SER %	MER %	LER %	χ2
10413	Kinney 74	10	4.07 – 8.56	15.0	0.0	0.0	0.23
10413	Kinney 74	4	6.44 – 8.04	9.0	0.0	0.0	0.37
40139	Broder 64	3	2.70 – 3.05	25.0	0.0	0.0	0.48
40278*	Degtyarev 71	1	3.40	25.0	(total)		1.39
40531	Korzh 75	1	3.00	4.2	(total)		4.70

Table 4: Experimental data base for the inelastic scattering cross section with excitation of group of levels (MT=851) (* – from γ–transition measurements).

EXFOR ENTRY	Reference	Number of Points	Energy Range (MeV)	SER %	MER %	LER %	χ2
10413	Kinney 74	3	4.65 – 5.50	8.7	0.0	0.0	0.36
10676*	Van Patter 62	3	2.77 – 3.31	33.0	0.0	0.0	1.40

Table 5: Experimental data base for the total inelastic scattering cross section (* – from γ–transition measurements).

EXFOR ENTRY	Reference	Number of Points	Energy Range (MeV)	SER %	MER %	LER %
10492*	Karatzas 78	10	1.53 – 3.75	8.0	14.0	0.0
11676*	Van Patter 62	5	1.97 – 3.25	10.0	12.0	0.0
11672*	Scherrer 54	1	3.2	20.0.	(total)	
20905	Towle 67	1	7.0	5.0	(total)	
21373*	Beghian 55	1	2.5	35.0	(total)	
88020	Biryukov 75	1	9.1	11.0	(total)	
Evaluation	Vonach 91	1	14.0	2.0	(total)	
	Larson 85	19	1.42 – 19.8	6.2	0.0	3.0

Table 6:. Experimental data base for the evaluation of the cross-section for the ^{52}Cr(n,p)^{52}V reaction.

EXFOR Entry No.	Reference	Energy range (MeV)	No. of points	Method of measurement	Monitor	Correc-tions applied	Uncertainties(%) Statist. (uncorrel.)	Systematic (correl.)
11274	*Paul 53*	14.50	1	Act.,Beta-count.,Beta	Assoc.part.	1, 5	14(total)	
11464	*Kern 59*	12.33-18.24	21	Act.,NaI,Gamma	6Li(n,t)4He	1, 2	1.1-10.9	10.4-11.8
30403	*Khurana 59*	14.00	1	Act.	56Fe(n,p)	1,4-6	20(total)	
20004	*Allan 61*	14.00	1	Calc.of p by track det.	54Fe(n,p)	6	20(total)	
11132	*Chittenden 61*	14.80	1	Act.	No inform.	6	20(total)	
11263	*Strain 65*	14.70	1	Act.,NaI,Gamma	27Al(n,a)	6	20(total)	
11657	*Hussain 67*	14.80	1	Act.,NaI,Gamma	27Al(n,a)	1, 4-6	20(total)	
11536	*Clator 69*	14.40-16.70	3	Act,NaI,GeLi,Gamma	27Al(n,p)	1-2,4	10.4-15.5	16.3-19.9
30263	*Dresler 73*	14.60	1	Act.,NaI,Gamma	56Fe(n,p)	6	20(total)	
20673	*Valkonen 74*	14.70	1	Act.,GeLi,Gamma	27Al(n,p)	1, 4, 6	20(total)	
20721	*Qaim 76*	14.70	1	Act.,GeLi,Gamma	27Al(n,a)	4	5.6(total)	
30438	*Sailer 77*	14.81	1	Act.,GeLi,Gamma	27Al(n,a)	1,4-6	20(total)	
10900	*Smith 80*	5.34-8.94	22	Act.,GeLi,Gamma	238U(n,f)	4	2.2-16	8
88021	*Artem'ev 80*	14.80	1	Act.	27Al(n,a)	6	20(total)	
21936	*Bahal 84*	14.70	1	Act.,GeLi,Gamma	27Al(n,p)	1,4	6.0(total)	
30707	*Gupta 85*	14.80	1	Act.,Gam.scin.spectr.	56Fe(n,p)	4, 6	20(total)	
30810	*Hoang Dac Luc 86*	14.80	1	Act.,GeIn,Gamma	27Al(n,p)	4	8.2(total)	
11958	*Ghorai A 87*	14.20-18.20	5	Act.,GeLi,Gamma	27Al(n,a)	1, 3, 4	2.7-6.7	6.7-7.7
11958	*Ghorai B 87*	14.20	1	Act.,GeLi,Gamma	Assoc.part.		6	
22089	*Ikeda 88*	13.33-14.90	6	Act.,GeLi,Gamma	27Al(n,p)	4	3.3-7.3	3.6-4.3
22187	*Kawade 90*	13.40-14.87	6	Act.,GeLi,Gamma	27Al(n,p)	4	2.0-2.9	4.5-4.7
-	*Viennot 91*	13.77-14.83	4	Act.,GeLi,Gamma	27Al(n,p)	1, 3, 4	2.0	6.7-6.9

Correction codes:
1) correction from ^{53}Cr(n,np)^{52}V contribution;
2) shape measurements normalized to weighted average value of cross-sections provided by Ikeda et al. (*Ikeda 88*), Kawade et al. (*Kawade 90*), Viennot et al. (*Viennot 91*) at 14.74 MeV;
3) addition of error components ignored by author into reported total cross-section uncertainty;
4) renormalization of results to standard reference cross-section data;
5) renormalization to new values of decay constants; 6) cross-section uncertainty (20%) is assigned for obsolete measurements.

Table 7: Experimental data base for the non–elastic cross section

EXFOR ENTRY	Reference	Number of Points	Energy Range (MeV)	SER %	MER %	LER %
11217	Taylor 55	3	3.50 – 12.7	11.0	0.0	0.0
40647	Abramov 62	1	2.2	10.0	(total)	
Evaluation	Vonach 91	1	14.0	1.4	(total)	

Table 8: Experimental data base for the elastic scattering cross section

EXFOR ENTRY	Reference	Number of Points	Energy Range (MeV)	SER %	MER %	LER %
10413	Kinney 74	5	4.34 – 8.56	6.2	0.0	4.2
11511	Becker 66	1	3.2	10.0	(total)	
Evaluation	Vonach 91	1	14.0	2.0	(total)	
12750	Guenther 82	10	1.55 – 3.75	8.9	0.0	6.0
20019	Holmqvist 69	9	2.47 – 8.05	12.4	0.0	8.4
22048	Olsson 87	1	21.6	5.0	(total)	
40101	Popov 71	1	4.37	10.0	(total)	
40311	Sokolov 73	1	2.63	14.0	(total)	
40372	Salnikov 57	1	2.34	8.0	(total)	
40706	Kazakova 65	1	2.0	10.0	(total)	
10413	Kinney 74	3	6.44 – 8.56	6.2	0.0	4.2
40531	Korzh 75	4	1.50 – 3.00	10.0	0.0	6.7
40551	Korzh 77	3	5.00 – 7.00	7.4	0.0	5.0
40045	Pasechnik 69	1	2.9	12.0	(total)	

Table 9: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	total (MT = 1) group average (barn)	elastic scattering (MT = 2) (barn)
0.637–0.8	2.6515 ± 0.015	2.6487 ± 0.015
0.8–1.0	3.1379 ± 0.022	3.1351 ± 0.022
1.0–1.2	2.7348 ± 0.019	2.7319 ± 0.019
1.2–1.4	3.2360 ± 0.024	3.2329 ± 0.024
1.4–1.6	3.5200 ± 0.023	3.3655 ± 0.028
1.6–1.8	3.3192 ± 0.021	2.9089 ± 0.040
1.8–2.0	3.0096 ± 0.018	2.4880 ± 0.035
2.0–2.2	3.4857 ± 0.021	2.8224 ± 0.038
2.2–2.4	3.4214 ± 0.019	2.7333 ± 0.041
2.4–2.6	3.6940 ± 0.020	2.9734 ± 0.033
2.6–2.8	3.8027 ± 0.020	2.9703 ± 0.051
2.8–3.0	3.6366 ± 0.019	2.7591 ± 0.034
3.0–3.5	3.7432 ± 0.014	2.7479 ± 0.036
3.5–4.0	3.7205 ± 0.014	2.5590 ± 0.050
4.0–4.5	3.7550 ± 0.014	2.5140 ± 0.061
4.5–5.0	3.7673 ± 0.015	2.4593 ± 0.043
5.0–5.5	3.6879 ± 0.017	2.3143 ± 0.058
5.5–6.0	3.6289 ± 0.018	2.2108 ± 0.071
6.0–6.5	3.5625 ± 0.017	2.1431 ± 0.067
6.5–7.0	3.5133 ± 0.016	2.1161 ± 0.054
7.0–7.5	3.4158 ± 0.016	2.0123 ± 0.051
7.5–8.0	3.2846 ± 0.016	1.8824 ± 0.052
8.0–8.5	3.1920 ± 0.016	1.8005 ± 0.053
8.5–9.0	3.1026 ± 0.015	1.7090 ± 0.052
9.0–9.5	3.0249 ± 0.015	1.6390 ± 0.062
9.5–10.0	2.9368 ± 0.015	1.5587 ± 0.066
10.0–10.5	2.8657 ± 0.014	1.4867 ± 0.069
10.5–11.0	2.7958 ± 0.013	1.4169 ± 0.070
11.0–11.5	2.7498 ± 0.014	1.3761 ± 0.069
11.5–12.0	2.6586 ± 0.014	1.2823 ± 0.068
12.0–12.5	2.5883 ± 0.014	1.2179 ± 0.063
12.5–13.0	2.5328 ± 0.015	1.1731 ± 0.055
13.0–13.5	2.5052 ± 0.015	1.1339 ± 0.045
13.5–14.0	2.4674 ± 0.016	1.1064 ± 0.026
14.0–14.5	2.4031 ± 0.010	1.0183 ± 0.024
14.5–15.0	2.3723 ± 0.017	0.9822 ± 0.041
15.0–16.0	2.3082 ± 0.018	0.9283 ± 0.056
16.0–17.0	2.2599 ± 0.019	0.9190 ± 0.079
17.0–18.0	2.2186 ± 0.020	0.9176 ± 0.081
18.0–19.0	2.1950 ± 0.023	0.9345 ± 0.073
19.0–20.0	2.1873 ± 0.021	0.9555 ± 0.046

Table 10: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	nonelastic (barn)	total inelastic (barn)
0.925	0.0029 ± 0.001	
1.100	0.0029 ± 0.001	
1.300	0.0031 ± 0.001	
1.462		0.0000 ± 0.000
1.500	0.1545 ± 0.015	0.1515 ± 0.015
1.700	0.4103 ± 0.035	0.4082 ± 0.035
1.900	0.5216 ± 0.030	0.5198 ± 0.029
2.100	0.6633 ± 0.032	0.6616 ± 0.032
2.300	0.6881 ± 0.036	0.6864 ± 0.036
2.500	0.7206 ± 0.027	0.7190 ± 0.027
2.700	0.8324 ± 0.048	0.8309 ± 0.047
2.900	0.8775 ± 0.028	0.8760 ± 0.028
3.250	0.9953 ± 0.033	0.9940 ± 0.033
3.750	1.1615 ± 0.049	1.1603 ± 0.048
4.250	1.2410 ± 0.060	1.2398 ± 0.060
4.750	1.3080 ± 0.041	1.3063 ± 0.041
5.250	1.3736 ± 0.056	1.3698 ± 0.056
5.750	1.4181 ± 0.070	1.4088 ± 0.070
6.250	1.4194 ± 0.066	1.4019 ± 0.066
6.750	1.3972 ± 0.053	1.3693 ± 0.053
7.250	1.4035 ± 0.050	1.3694 ± 0.050
7.750	1.4022 ± 0.051	1.3628 ± 0.051
8.250	1.3915 ± 0.052	1.3479 ± 0.052
8.750	1.3936 ± 0.051	1.3434 ± 0.051
9.250	1.3859 ± 0.060	1.3283 ± 0.060
9.750	1.3781 ± 0.065	1.3151 ± 0.065
10.250	1.3790 ± 0.068	1.3090 ± 0.067
10.750	1.3789 ± 0.069	1.3048 ± 0.068
11.250	1.3737 ± 0.068	1.2948 ± 0.067
11.750	1.3763 ± 0.066	1.2924 ± 0.065
12.250	1.3704 ± 0.062	1.2672 ± 0.061
12.750	1.3597 ± 0.054	1.1954 ± 0.053
13.250	1.3713 ± 0.043	1.1057 ± 0.043
13.750	1.3610 ± 0.023	0.9904 ± 0.024
14.250	1.3848 ± 0.023	0.8774 ± 0.023
14.750	1.3901 ± 0.038	0.7763 ± 0.033
15.500	1.3799 ± 0.053	0.6406 ± 0.035
16.500	1.3409 ± 0.077	0.5051 ± 0.033
17.500	1.3010 ± 0.079	0.4134 ± 0.030
18.500	1.2605 ± 0.072	0.3505 ± 0.026
19.500	1.2318 ± 0.049	0.3075 ± 0.021

Table 11: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	(n,n_1), MT = 51 (millibarn)	(n,n_2), MT = 52 (millibarn)
1.462	0.0000 ± 0.000	
1.500	151.4800 ± 15.140	
1.700	408.2400 ± 34.540	
1.900	519.8300 ± 29.870	
2.100	661.5600 ± 32.260	
2.300	686.4100 ± 36.420	
2.408		0.0000 ± 0.000
2.500	699.3100 ± 26.880	19.7120 ± 2.263
2.700	781.1000 ± 47.570	49.1120 ± 5.027
2.900	724.3600 ± 27.350	83.7920 ± 4.899
3.250	583.6600 ± 33.540	114.9900 ± 9.484
3.750	487.0900 ± 34.410	134.1500 ± 14.580
4.250	380.5000 ± 23.850	135.8200 ± 10.830
4.750	300.3800 ± 18.550	125.6400 ± 9.797
5.250	220.6500 ± 18.580	104.1500 ± 10.530
5.750	181.7800 ± 17.190	83.9240 ± 10.590
6.250	150.2800 ± 15.910	65.1150 ± 6.252
6.750	118.3900 ± 14.450	48.6830 ± 4.838
7.250	105.6700 ± 14.460	37.2860 ± 3.499
7.750	94.2170 ± 16.540	29.8040 ± 3.003
8.250	82.7250 ± 17.720	24.7270 ± 3.318
8.750	81.9870 ± 18.190	20.6190 ± 3.044
9.250	75.8390 ± 28.610	17.0600 ± 4.573
9.750	75.0900 ± 31.150	14.3340 ± 4.611
10.250	73.8830 ± 32.120	12.4550 ± 4.510
10.750	70.7690 ± 31.880	11.1490 ± 4.354
11.250	65.9960 ± 30.310	10.2650 ± 4.184
11.750	68.6280 ± 29.470	9.6271 ± 4.053
12.250	64.6560 ± 26.560	9.0911 ± 3.947
12.750	59.2630 ± 23.710	8.4034 ± 3.817
13.250	57.8510 ± 19.760	7.6732 ± 3.659
13.750	54.4540 ± 11.700	7.0524 ± 3.442
14.250	53.6280 ± 11.570	6.7524 ± 3.294
14.750	54.2800 ± 18.230	6.4422 ± 3.138
15.500	54.7290 ± 21.520	5.8658 ± 2.852
16.500	58.0180 ± 23.580	5.3451 ± 2.593
17.500	61.1570 ± 23.110	5.1624 ± 2.498
18.500	63.5550 ± 20.360	5.0395 ± 2.435
19.500	64.9660 ± 15.070	4.9002 ± 2.367
20.000	64.3940 ± 14.930	4.8557 ± 2.346

Table 12: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	(n,n_{3-7}), MT = 851 (millibarn)	$(n,n_{8\leq 11})$, MT = 852 (millibarn)
2.698	0.0000 ± 0.000	
2.900	67.8480 ± 8.260	
3.250	295.3000 ± 24.120	
3.491		0.0000 ± 0.000
3.750	491.6300 ± 45.960	47.4100 ± 6.828
4.250	467.1400 ± 51.460	171.7400 ± 24.100
4.750	462.1600 ± 32.580	240.1400 ± 30.180
5.250	379.7900 ± 22.930	249.3400 ± 36.350
5.750	300.3100 ± 36.910	227.6400 ± 45.510
6.250	222.4700 ± 45.400	187.8000 ± 47.990
6.750	160.7700 ± 35.810	146.8900 ± 38.210
7.250	118.6100 ± 32.050	116.1300 ± 35.150
7.750	86.9410 ± 24.540	91.0680 ± 28.010
8.250	62.3840 ± 21.690	71.7310 ± 25.780
8.750	45.8560 ± 16.720	57.7090 ± 21.180
9.250	34.5550 ± 16.240	47.3420 ± 22.260
9.750	26.3650 ± 12.810	39.3590 ± 19.230
10.250	20.8520 ± 10.290	33.9460 ± 16.970
10.750	16.9460 ± 8.410	30.1450 ± 15.230
11.250	14.1980 ± 7.015	27.4510 ± 13.870
11.750	12.1200 ± 5.970	25.2910 ± 12.790
12.250	10.4890 ± 5.196	23.3950 ± 11.940
12.750	9.2780 ± 4.622	21.8630 ± 11.240
13.250	8.3283 ± 4.150	20.7610 ± 10.660
13.750	7.5154 ± 3.753	19.8650 ± 10.200
14.250	6.8886 ± 3.440	18.9290 ± 9.706
14.750	6.3878 ± 3.184	18.1170 ± 9.278
15.500	5.6466 ± 2.809	16.6320 ± 8.501
16.500	4.9882 ± 2.473	15.2580 ± 7.765
17.500	4.5597 ± 2.253	14.1570 ± 7.160
18.500	4.4231 ± 2.182	13.2610 ± 6.682
19.500	4.2693 ± 2.105	12.9500 ± 6.522
20.000	4.2511 ± 2.097	12.8800 ± 6.487

Table 13: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	(n,n_{12-15}), MT = 853 (millibarn)	(n,n_{16}), MT = 66 (millibarn)
4.023	0.0000 ± 0.000	
4.250	84.5970 ± 12.270	
4.652		0.0000 ± 0.000
4.750	148.2500 ± 20.380	29.7740 ± 4.409
5.250	172.1900 ± 26.530	55.9790 ± 9.152
5.750	167.0200 ± 35.520	58.2550 ± 13.290
6.250	140.4600 ± 38.440	53.0030 ± 15.610
6.750	108.5000 ± 30.140	44.8760 ± 13.280
7.250	82.0340 ± 26.550	37.7930 ± 13.020
7.750	60.6900 ± 19.810	32.0900 ± 11.050
8.250	44.6200 ± 16.870	27.8020 ± 10.980
8.750	33.2990 ± 12.740	24.7560 ± 9.798
9.250	25.2020 ± 12.210	22.5250 ± 11.190
9.750	19.1180 ± 9.449	20.9360 ± 10.400
10.250	14.9160 ± 7.454	19.8590 ± 9.754
10.750	12.0210 ± 6.027	19.0830 ± 9.139
11.250	9.9340 ± 4.963	18.5660 ± 8.535
11.750	8.3473 ± 4.160	18.1460 ± 7.876
12.250	7.1160 ± 3.560	17.7800 ± 7.137
12.750	6.1942 ± 3.111	17.4580 ± 6.248
13.250	5.5089 ± 2.767	17.3040 ± 5.129
13.750	4.9771 ± 2.504	17.1350 ± 3.072
14.250	4.5693 ± 2.299	17.0640 ± 3.065
14.750	4.2351 ± 2.128	16.9920 ± 5.024
15.500	3.7717 ± 1.892	16.6610 ± 6.329
16.500	3.3376 ± 1.670	16.2470 ± 7.292
17.500	3.0180 ± 1.507	15.8550 ± 7.728
18.500	2.7537 ± 1.373	15.4000 ± 7.787
19.500	2.6119 ± 1.302	15.0770 ± 7.666
20.000	2.6059 ± 1.299	15.0080 ± 7.632

Table 14: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	(n,n_{cont}), MT = 91 (millibarn)	(n,γ), MT = 102) (millibarn)
0.850		2.8280 ± 0.843
0.900		2.8597 ± 0.854
1.100		2.9358 ± 0.877
1.300		3.1430 ± 0.938
1.500		2.9898 ± 0.892
1.700		2.0753 ± 0.619
1.900		1.7416 ± 0.520
2.100		1.7186 ± 0.513
2.300		1.7302 ± 0.516
2.500		1.5854 ± 0.473
2.700		1.4978 ± 0.446
2.900		1.4613 ± 0.435
3.250		1.3355 ± 0.398
3.750		1.2437 ± 0.493
4.250		1.1951 ± 0.474
4.750		1.1592 ± 0.573
4.836	0.0000 ± 0.000	
5.250	187.7500 ± 22.500	1.0314 ± 0.511
5.750	389.8900 ± 36.710	0.9114 ± 0.452
6.250	582.7500 ± 42.440	0.8167 ± 0.406
6.750	741.2000 ± 45.320	0.7445 ± 0.370
7.250	871.8600 ± 44.790	0.6847 ± 0.341
7.750	967.9600 ± 45.030	0.6342 ± 0.316
8.250	1033.9000 ± 44.850	0.5932 ± 0.296
8.750	1079.2000 ± 46.330	0.5616 ± 0.281
9.250	1105.8000 ± 49.850	0.5393 ± 0.269
9.750	1119.9000 ± 53.400	0.5260 ± 0.263
10.250	1133.1000 ± 55.820	0.5245 ± 0.262
10.750	1144.7000 ± 57.100	0.5349 ± 0.267
11.250	1148.4000 ± 57.350	0.5550 ± 0.277
11.750	1150.2000 ± 56.860	0.5822 ± 0.291
12.250	1134.7000 ± 54.970	0.6154 ± 0.307
12.750	1072.9000 ± 48.350	0.6501 ± 0.325
13.250	988.2500 ± 39.620	0.6835 ± 0.341
13.750	879.3700 ± 25.030	0.7151 ± 0.357
14.250	769.5200 ± 22.720	0.7420 ± 0.370
14.750	669.8300 ± 27.420	0.7629 ± 0.381
15.500	537.3200 ± 26.250	0.7753 ± 0.387
16.500	401.9000 ± 20.100	0.7699 ± 0.385
17.500	309.4500 ± 15.470	0.7402 ± 0.370
18.500	246.1100 ± 12.310	0.6826 ± 0.341
19.500	202.7700 ± 10.130	0.5937 ± 0.297
20.000	199.4700 ± 9.972	0.5494 ± 0.275

Table 15: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	(n,p), MT = 103 (millibarn)	(n,α), MT = 107 (millibarn)
1.234		0.0000 ± 0.000
3.257	0.0000 ± 0.000	
4.250	0.0193 ± 0.003	
4.750	0.4763 ± 0.074	0.0016 ± 0.001
5.250	2.6920 ± 0.350	0.0141 ± 0.011
5.750	8.2739 ± 0.733	0.0649 ± 0.052
6.250	16.5400 ± 1.169	0.2137 ± 0.171
6.750	26.5590 ± 1.814	0.5733 ± 0.458
7.250	32.2030 ± 2.242	1.1899 ± 0.950
7.750	36.7350 ± 2.496	2.0763 ± 1.658
8.250	39.8310 ± 2.698	3.1530 ± 2.528
8.750	45.1920 ± 2.899	4.3291 ± 3.481
9.250	51.3520 ± 4.028	5.5960 ± 4.502
9.750	55.2830 ± 5.047	7.0164 ± 5.627
10.250	60.3730 ± 5.853	8.7240 ± 6.886
10.750	62.2740 ± 6.350	10.6920 ± 8.259
11.250	64.4290 ± 6.520	12.7690 ± 7.256
11.750	66.5140 ± 6.161	15.2430 ± 8.390
12.250	75.3210 ± 4.445	17.7430 ± 6.360
12.750	76.7120 ± 4.740	20.7880 ± 7.119
13.250	78.1110 ± 2.933	23.6850 ± 3.918
13.750	78.1460 ± 2.118	27.2000 ± 4.201
14.250	75.6210 ± 1.909	30.9080 ± 4.387
14.750	75.2710 ± 1.639	34.7720 ± 4.431
15.500	69.1350 ± 2.898	40.1420 ± 7.020
16.500	58.0680 ± 2.408	45.5060 ± 10.720
17.500	47.7420 ± 2.251	47.1380 ± 13.920
18.500	43.9020 ± 2.610	44.1710 ± 15.630
19.500	40.5490 ± 5.853	38.2740 ± 15.640
20.000	37.5360 ± 5.423	35.7940 ± 14.640

Table 16: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	(n,2n), MT = 16 (millibarn)	(n,np), MT = 28 (millibarn)
8.440		0.0000 ± 0.000
11.750		0.5000 ± 0.207
12.250		7.8958 ± 3.042
12.271	0.0000 ± 0.000	
12.750	42.3390 ± 8.369	21.4580 ± 7.525
13.250	121.5900 ± 7.165	38.1380 ± 11.740
13.750	200.0700 ± 8.365	59.6370 ± 15.210
14.250	310.5600 ± 6.662	83.2050 ± 18.030
14.750	391.1100 ± 10.400	104.3500 ± 20.240
15.500	488.4800 ± 10.690	131.9400 ± 38.280
16.500	563.8200 ± 35.510	155.8300 ± 59.690
17.500	610.2000 ± 22.580	163.6200 ± 70.950
18.500	632.7800 ± 22.080	160.0300 ± 69.500
19.500	645.9300 ± 20.480	157.5700 ± 56.800
20.000	652.7900 ± 20.690	163.0300 ± 58.750

Table 17: Present evaluation for ^{52}Cr: cross sections and uncertainties

incid. Energy (MeV)	(n,d), MT = 104 (millibarn)	(n,nα), MT = 22 (millibarn)
8.442	0.0000 ± 0.000	
9.326		0.0000 ± 0.000
9.750	0.0100 ± 0.004	
10.250	0.0670 ± 0.027	
10.750	0.2790 ± 0.112	
11.250	0.6697 ± 0.268	
11.750	1.0570 ± 0.423	
12.250	1.5998 ± 0.640	
12.750	2.3602 ± 0.941	
13.250	3.4213 ± 1.359	0.0024 ± 0.001
13.750	4.8253 ± 1.908	0.0063 ± 0.003
14.250	6.3681 ± 2.515	0.0260 ± 0.013
14.750	7.4599 ± 2.957	0.0963 ± 0.048
15.250	8.0396 ± 3.199	
15.500		0.5665 ± 0.286
15.750	8.5222 ± 3.403	
16.250	8.9000 ± 3.560	
16.500		2.8120 ± 1.428
16.750	9.1750 ± 3.670	
17.250	9.4390 ± 3.776	
17.500		8.6065 ± 4.402
17.750	9.6680 ± 3.873	
18.250	9.8627 ± 3.960	
18.500		18.4610 ± 9.505
19.250	10.1860 ± 4.106	
19.500		31.0290 ± 16.060
20.000	10.4330 ± 4.202	37.3840 ± 19.320

Table 18: New experimental data for ^{56}Fe added to the evaluation of Ref. 2

Type of data	Neutr. En (MeV)	Remarks	Number of Data Points	Covariance Information	Reference
σ_{tot}	0.85 – 20	accurate high–resolut. data (0.004 nsec/m, syst. uncertainties ≈ 1%)	24.081	constructed from detailed uncertainty information supplied by authors	Weigmann 94
σ_{el}, $\sigma_{n,nl}$, $\sigma_{n,n2}$, $\sigma_{n,n3}$, $\sigma_{n,n4-7}$, $\sigma_{n,n8-14}$, $\sigma_{n,n15-32}$	6.0 – 14	Accurate absolute cross section measurements with carefully calibrated detectors, syst. uncert. ≈ 3%	84	complete covariance information supplied by authors	Mannhart 94
$\sigma_{\alpha-em}$ $\sigma_{\alpha-em}$ $\sigma_{He-prod}$	thresh – 20 thresh–14 10	uncertainty ≈ 10% uncertainty ≈ 10% uncertainty ≈ 12%	25 11 1	constructed from information on random and syst. errors supplied by authors	Haight 94 Baba 94 Haight 94b

Table 19: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	total, MT = 1 group average (barn)	elastic scattering, MT = 2 (barn)
0.862–1.00	2.4523 ± 0.022	2.2229 ± 0.022
1.0–1.2	2.5936 ± 0.022	2.1607 ± 0.023
1.2–1.4	2.9277 ± 0.021	2.4331 ± 0.022
1.4–1.6	3.0405 ± 0.021	2.3280 ± 0.022
1.6–1.8	2.9190 ± 0.019	2.2510 ± 0.022
1.8–2.0	3.0765 ± 0.019	2.3166 ± 0.022
2.0–2.2	3.2579 ± 0.019	2.3629 ± 0.021
2.2–2.4	3.1924 ± 0.018	2.2790 ± 0.021
2.4–2.6	3.7239 ± 0.020	2.7340 ± 0.023
2.6–2.8	3.3848 ± 0.018	2.4409 ± 0.020
2.8–3.0	3.3296 ± 0.017	2.3186 ± 0.020
3.0–3.5	3.4719 ± 0.017	2.3598 ± 0.022
3.5–4.0	3.5010 ± 0.017	2.2605 ± 0.023
4.0–4.5	3.6374 ± 0.019	2.3091 ± 0.024
4.5–5.0	3.6532 ± 0.018	2.2497 ± 0.026
5.0–5.5	3.6473 ± 0.019	2.1867 ± 0.028
5.5–6.0	3.6376 ± 0.018	2.1591 ± 0.029
6.0–6.5	3.5863 ± 0.018	2.1121 ± 0.028
6.5–7.0	3.5544 ± 0.017	2.0946 ± 0.026
7.0–7.5	3.4756 ± 0.017	2.0311 ± 0.024
7.5–8.0	3.4181 ± 0.016	1.9855 ± 0.025
8.0–8.5	3.3255 ± 0.016	1.8980 ± 0.025
8.5–9.0	3.2238 ± 0.016	1.8003 ± 0.024
9.0–9.5	3.1675 ± 0.017	1.7465 ± 0.023
9.5–10.0	3.0912 ± 0.017	1.6755 ± 0.022
10.0–10.5	3.0204 ± 0.018	1.6062 ± 0.022
10.5–11.0	2.9658 ± 0.018	1.5491 ± 0.022
11.0–11.5	2.8964 ± 0.019	1.4748 ± 0.022
11.5–12.0	2.8335 ± 0.019	1.4049 ± 0.022
12.0–12.5	2.7605 ± 0.019	1.3238 ± 0.021
12.5–13.0	2.6995 ± 0.018	1.2594 ± 0.022
13.0–13.5	2.6458 ± 0.017	1.2063 ± 0.020
13.5–14.0	2.6024 ± 0.016	1.1705 ± 0.017
14.0–14.5	2.5692 ± 0.018	1.1498 ± 0.018
14.5–15.0	2.5260 ± 0.021	1.1180 ± 0.023
15.0–16.0	2.4461 ± 0.026	1.0710 ± 0.025
16.0–17.0	2.3311 ± 0.030	0.9800 ± 0.038
17.0–18.0	2.2941 ± 0.042	0.9594 ± 0.054
18.0–19.0	2.2587 ± 0.034	0.9489 ± 0.045
19.0–20.0	2.2358 ± 0.034	0.9517 ± 0.035

Table 20: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	nonelastic, MT = 3 (barn)	total inelastic, MT = 4 (barn)
0.925	0.2295 ± 0.004	0.2261 ± 0.004
1.100	0.4329 ± 0.008	0.4306 ± 0.008
1.300	0.4946 ± 0.009	0.4925 ± 0.010
1.500	0.7125 ± 0.010	0.7105 ± 0.010
1.700	0.6679 ± 0.013	0.6659 ± 0.013
1.900	0.7599 ± 0.013	0.7578 ± 0.013
2.100	0.8949 ± 0.013	0.8928 ± 0.013
2.300	0.9134 ± 0.013	0.9113 ± 0.013
2.500	0.9899 ± 0.014	0.9887 ± 0.014
2.700	0.9439 ± 0.012	0.9416 ± 0.012
2.900	1.0110 ± 0.014	1.0087 ± 0.014
3.250	1.1121 ± 0.016	1.1102 ± 0.016
3.750	1.2405 ± 0.016	1.2388 ± 0.016
4.250	1.3283 ± 0.018	1.3268 ± 0.018
4.750	1.4035 ± 0.020	1.4016 ± 0.020
5.250	1.4606 ± 0.023	1.4571 ± 0.023
5.750	1.4785 ± 0.025	1.4679 ± 0.025
6.250	1.4742 ± 0.024	1.4521 ± 0.024
6.750	1.4598 ± 0.021	1.4258 ± 0.021
7.250	1.4445 ± 0.020	1.4031 ± 0.020
7.750	1.4326 ± 0.021	1.3782 ± 0.020
8.250	1.4275 ± 0.022	1.3675 ± 0.022
8.750	1.4235 ± 0.022	1.3488 ± 0.022
9.250	1.4210 ± 0.022	1.3394 ± 0.022
9.750	1.4157 ± 0.022	1.3259 ± 0.022
10.250	1.4142 ± 0.022	1.3144 ± 0.022
10.750	1.4167 ± 0.022	1.3090 ± 0.022
11.250	1.4216 ± 0.022	1.2995 ± 0.022
11.750	1.4286 ± 0.021	1.2714 ± 0.021
12.250	1.4367 ± 0.020	1.2088 ± 0.020
12.750	1.4401 ± 0.018	1.0981 ± 0.019
13.250	1.4395 ± 0.015	0.9595 ± 0.018
13.750	1.4319 ± 0.011	0.8535 ± 0.017
14.250	1.4194 ± 0.013	0.7547 ± 0.018
14.750	1.4080 ± 0.018	0.6770 ± 0.020
15.500	1.3751 ± 0.020	0.5457 ± 0.025
16.500	1.3511 ± 0.028	0.4188 ± 0.029
17.500	1.3347 ± 0.037	0.3469 ± 0.019
18.500	1.3098 ± 0.033	0.3003 ± 0.029
19.500	1.2841 ± 0.022	0.2640 ± 0.013

Table 21: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	(n,n_1), MT = 51 (millibarn)	(n,n_2), MT = 52 (millibarn)
0.862	0.0000 ± 0.000	
0.925	226.1400 ± 3.637	
1.100	430.5900 ± 8.115	
1.300	492.5200 ± 9.508	
1.500	710.5300 ± 10.010	
1.700	665.9200 ± 12.640	
1.900	757.7700 ± 12.840	
2.100	892.7800 ± 12.750	
2.123		0.0000 ± 0.000
2.300	888.5500 ± 12.990	22.7630 ± 1.258
2.500	940.4700 ± 14.550	47.2530 ± 2.033
2.700	863.0300 ± 12.510	78.6290 ± 2.765
2.900	762.8700 ± 15.120	110.3000 ± 3.075
3.250	625.1700 ± 16.880	124.1400 ± 4.616
3.750	442.7700 ± 15.320	131.1600 ± 7.087
4.250	322.9300 ± 14.100	126.5900 ± 6.650
4.750	246.5900 ± 11.650	101.4100 ± 5.960
5.250	210.3200 ± 13.080	78.5760 ± 5.585
5.750	184.4500 ± 16.670	63.9000 ± 4.894
6.250	161.6600 ± 15.390	51.4450 ± 4.159
6.750	158.5300 ± 15.160	36.8640 ± 3.619
7.250	125.0000 ± 12.930	25.6680 ± 2.843
7.750	107.7100 ± 11.580	19.0430 ± 2.129
8.250	104.9900 ± 12.690	15.2900 ± 1.639
8.750	100.4600 ± 13.200	12.5520 ± 1.274
9.250	99.5250 ± 2.997	10.0110 ± 0.885
9.750	92.6050 ± 3.318	8.7923 ± 0.839
10.250	89.6530 ± 2.546	7.7663 ± 0.699
10.750	89.3270 ± 2.370	7.5571 ± 0.509
11.250	84.0310 ± 2.167	6.7028 ± 0.487
11.750	78.0800 ± 2.475	5.9253 ± 0.652
12.250	77.4860 ± 3.277	5.3434 ± 0.716
12.750	76.5990 ± 4.443	4.9715 ± 0.845
13.250	73.4860 ± 4.534	4.6910 ± 0.775
13.750	73.6530 ± 3.321	5.3488 ± 0.657
14.250	72.6700 ± 2.477	4.5581 ± 0.676
14.750	72.5620 ± 2.727	5.0730 ± 0.633
15.500	68.9090 ± 3.702	4.3570 ± 0.896
16.500	69.6350 ± 6.508	3.7064 ± 1.489
17.500	69.0940 ± 7.646	3.3661 ± 1.791
18.500	67.5490 ± 6.871	3.1220 ± 1.834
19.500	65.5570 ± 6.631	3.0365 ± 2.196
20.000	64.7700 ± 6.565	3.0320 ± 2.193

Table 22: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	(n,n_3), MT = 53 (millibarn)			(n,n_{4-7}), MT = 851 (millibarn)		
2.706	0.0000	±	0.000			
2.900	137.4300	±	7.878			
2.995				0.0000	±	0.000
3.250	166.6000	±	8.753	196.4300	±	12.750
3.750	159.4800	±	8.436	300.6400	±	12.930
4.250	133.1500	±	7.992	287.5300	±	9.660
4.750	107.2500	±	8.025	247.2100	±	10.810
5.250	77.3100	±	6.889	202.0700	±	8.131
5.750	60.2710	±	6.080	170.6500	±	5.417
6.250	47.3370	±	5.578	132.5600	±	3.701
6.750	36.5520	±	4.733	87.2410	±	3.030
7.250	27.9110	±	3.829	56.7970	±	1.182
7.750	21.9530	±	3.017	43.8750	±	0.832
8.250	17.8510	±	2.483	39.2070	±	0.955
8.750	14.2060	±	1.866	34.5470	±	0.799
9.250	10.8290	±	0.960	28.0720	±	1.339
9.750	9.3355	±	0.888	22.2810	±	1.388
10.250	8.0193	±	0.726	18.1380	±	1.159
10.750	7.2856	±	0.494	15.7730	±	0.822
11.250	6.5182	±	0.482	14.3950	±	0.782
11.750	5.2601	±	0.663	12.4870	±	1.011
12.250	4.9101	±	0.760	11.0230	±	1.317
12.750	5.3171	±	1.129	9.9027	±	1.781
13.250	4.7996	±	1.394	8.5683	±	1.621
13.750	4.7089	±	0.695	9.1055	±	1.450
14.250	4.5105	±	0.720	8.8024	±	1.062
14.750	4.4526	±	0.673	9.4961	±	0.980
15.500	3.8784	±	0.944	9.2320	±	1.383
16.500	3.3753	±	2.056	8.4254	±	3.229
17.500	2.9647	±	2.431	7.3512	±	3.869
18.500	2.8782	±	2.585	6.9452	±	4.100
19.500	2.7488	±	3.059	6.6722	±	4.879
20.000	2.7586	±	3.057	6.6800	±	4.877

Table 23: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	(n,n_{8-14}), MT = 852 (millibarn)	(n,n_{15-32}), MT = 853 (millibarn)
3.431	0.0000 ± 0.000	
3.750	200.3800 ± 18.050	0.0000 ± 0.000
4.250	316.6300 ± 20.600	138.9500 ± 19.560
4.750	322.5400 ± 23.790	335.7700 ± 33.910
5.250	299.1100 ± 22.830	390.3500 ± 60.830
5.750	233.2800 ± 17.640	378.5300 ± 93.130
6.250	172.8100 ± 11.720	335.1200 ± 105.600
6.750	117.7100 ± 10.520	277.6900 ± 104.800
7.250	77.7210 ± 6.214	226.3700 ± 93.050
7.750	58.0250 ± 4.978	178.5200 ± 68.540
8.250	47.1910 ± 5.912	139.4700 ± 44.630
8.750	39.0710 ± 4.820	108.3300 ± 25.520
9.250	31.6570 ± 2.410	84.2340 ± 7.289
9.750	24.8570 ± 1.809	68.8520 ± 6.228
10.250	19.9710 ± 1.439	53.0800 ± 5.486
10.750	16.7760 ± 0.955	42.5930 ± 3.999
11.250	14.7980 ± 0.871	37.7600 ± 3.172
11.750	11.5130 ± 0.997	33.6130 ± 3.400
12.250	9.6042 ± 1.320	30.4550 ± 3.170
12.750	8.4453 ± 1.695	24.8310 ± 4.027
13.250	7.8681 ± 1.481	20.7090 ± 4.247
13.750	7.8030 ± 1.161	20.8870 ± 3.923
14.250	7.4511 ± 0.863	19.9900 ± 3.378
14.750	6.8107 ± 0.647	20.0000 ± 2.090
15.500	7.5204 ± 1.106	17.9320 ± 2.656
16.500	8.5101 ± 2.093	19.5590 ± 8.826
17.500	8.8872 ± 1.624	21.4030 ± 11.970
18.500	8.8652 ± 2.801	22.6660 ± 12.580
19.500	8.5768 ± 3.341	22.7330 ± 14.970
20.000	8.5248 ± 3.335	23.4920 ± 15.320

Table 24: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	(n,n_{cont}), MT = 91 (millibarn)	(n,γ), MT = 102 (millibarn)
0.862		3.9972 ± 0.800
1.000		2.4452 ± 0.489
1.250		2.0590 ± 0.412
1.500		2.0015 ± 0.400
1.750		2.0380 ± 0.408
2.000		2.1519 ± 0.431
2.123		2.1835 ± 0.437
2.250		2.0978 ± 0.420
2.500		2.1633 ± 0.433
2.706		2.2542 ± 0.451
3.000		2.2300 ± 0.446
3.125		2.1031 ± 0.421
3.179		1.9155 ± 0.383
3.431		1.7851 ± 0.357
3.508		1.7287 ± 0.450
4.000		1.4840 ± 0.476
4.378		1.4190 ± 0.455
4.398		1.4158 ± 0.454
4.449		1.4021 ± 0.450
4.500		1.3570 ± 0.517
4.618	0.0000 ± 0.000	
4.696	14.5900 ± 4.092	1.2409 ± 0.473
4.750	36.9650 ± 10.400	
4.795	42.6000 ± 11.910	
5.000		1.1428 ± 0.504
5.250	197.5500 ± 52.160	1.0595 ± 0.467
5.500		0.9938 ± 0.497
5.750	381.4800 ± 90.550	0.9382 ± 0.470
6.000		0.8930 ± 0.446
6.250	558.9800 ± 105.500	
6.500		0.8274 ± 0.414
6.750	724.9700 ± 106.100	
7.000		0.7735 ± 0.387
7.250	874.8700 ± 94.740	
7.500		0.7316 ± 0.366
7.750	953.8400 ± 71.480	
8.000		0.7028 ± 0.352
8.250	1002.5000 ± 50.140	
8.500		0.6867 ± 0.344
8.750	1034.9000 ± 35.310	
9.000		0.6809 ± 0.341
9.250	1069.3000 ± 22.620	
9.500		0.6810 ± 0.341
9.750	1093.1000 ± 22.550	

<u>Table 24 (cont.):</u> Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	(n,n_{cont}), MT = 91 (millibarn)	(n,γ), MT = 102 (millibarn)
10.000		0.6823 ± 0.342
10.250	1111.5000 ± 22.400	
10.500		0.6903 ± 0.346
10.750	1123.0000 ± 22.020	
11.000		0.6997 ± 0.351
11.250	1126.6000 ± 22.060	
11.513		0.7131 ± 0.357
11.750	1112.9000 ± 22.200	
12.000		0.7281 ± 0.364
12.250	1055.6000 ± 22.180	0.7428 ± 0.370
12.500		
12.750	952.4800 ± 22.040	
13.000		0.7536 ± 0.326
13.250	835.8800 ± 21.220	
13.500		0.7624 ± 0.279
13.750	724.6300 ± 19.530	
14.000		0.7712 ± 0.231
14.250	635.6900 ± 18.000	
14.500		0.7775 ± 0.284
14.750	563.3300 ± 19.300	
15.000		0.7797 ± 0.337
15.500	438.1800 ± 24.800	0.7700 ± 0.332
16.000		0.7512 ± 0.374
16.500	301.2100 ± 30.470	0.7250 ± 0.361
17.000		0.6895 ± 0.344
17.500	229.1900 ± 23.650	0.6482 ± 0.324
18.000		0.6017 ± 0.301
18.500	185.1800 ± 31.470	0.5540 ± 0.277
19.000		0.5056 ± 0.253
19.500	151.5300 ± 20.910	0.4579 ± 0.229
20.000	145.4000 ± 20.080	0.4110 ± 0.206
20.375		0.3771 ± 0.189

Table 25: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	(n,p), MT = 103 (millibarn)			(n,α), MT = 107 (millibarn)		
0.333				0.0000	±	0.000
2.964	0.0000	±	0.000			
				0.0062	±	0.005
4.250	0.0363	±	0.002	0.0312	±	0.025
4.750	0.5492	±	0.015	0.1266	±	0.061
5.250	2.0100	±	0.060	0.5002	±	0.086
5.750	8.0565	±	0.201	1.5921	±	0.140
6.250	17.4110	±	0.413	3.7994	±	0.254
6.750	27.1180	±	0.533	6.0817	±	0.357
7.250	31.9600	±	0.724	8.6842	±	0.478
7.750	42.4180	±	0.887	11.2730	±	0.606
8.250	46.1450	±	0.981	13.1310	±	0.719
8.750	57.9460	±	1.612	16.1110	±	0.848
9.250	62.8790	±	2.120	18.0250	±	0.934
9.750	67.4920	±	2.168	21.6690	±	1.067
10.250	75.7260	±	2.228	23.2200	±	1.203
10.750	81.3720	±	2.140	25.2400	±	1.582
11.250	91.3580	±	2.439	29.1760	±	1.826
11.750	95.4510	±	2.310	31.1080	±	1.950
12.250	106.2400	±	2.077	33.9100	±	1.970
12.750	114.7100	±	1.631	35.6710	±	2.088
13.250	116.5600	±	1.364	39.4420	±	2.362
13.750	115.4800	±	0.808	39.2040	±	2.152
14.250	113.6000	±	0.989	41.8150	±	1.624
14.750	107.5500	±	0.474	43.1110	±	1.597
15.500	94.1880	±	0.935	43.1600	±	2.921
16.500	78.4120	±	0.687	37.2620	±	4.430
17.500	64.8350	±	0.765	31.7260	±	6.560
18.500	56.3160	±	0.837	28.5430	±	8.477
19.500	49.2100	±	0.806	23.2850	±	10.090
20.000	42.2270	±	0.694	18.9280	±	8.402

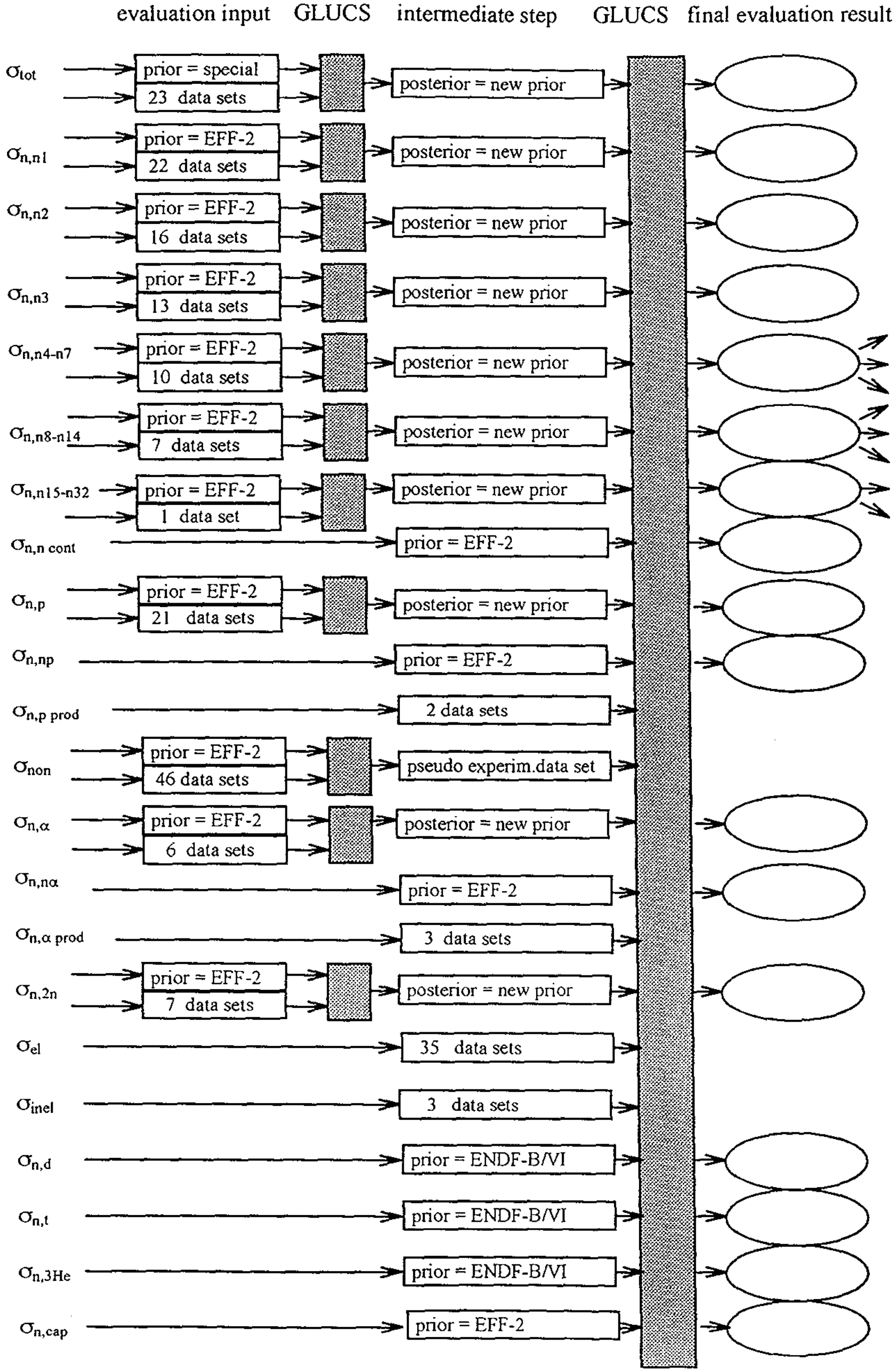
Table 26: Present evaluation for ^{56}Fe: cross sections and uncertainties

incid. Energy (MeV)	(n,2n), MT = 16 (millibarn)			(n,np), MT = 28 (millibarn)		
8.099				0.0000	±	0.000
11.399	0.0000	±	0.000			
11.513	2.9196	±	0.227	0.0379	±	0.018
12.000				0.8092	±	0.366
12.250	81.2800	±	3.626			
12.500				6.5813	±	2.803
12.750	175.5800	±	6.683			
13.000				17.8600	±	6.291
13.250	283.0400	±	10.390			
13.500				33.1180	±	9.041
13.699				40.9570	±	11.060
13.750	373.8200	±	12.740			
14.000				52.3440	±	10.600
14.250	438.1300	±	13.520			
14.359				68.4310	±	13.200
14.750	485.0300	±	14.450			
15.000				98.2430	±	17.290
15.500	557.2700	±	23.770	125.3600	±	23.480
16.000				137.8500	±	31.310
16.500	637.2200	±	36.130	154.0300	±	34.330
17.000				153.7400	±	47.370
17.500	680.4800	±	36.760	159.9500	±	43.400
18.000				161.7300	±	56.960
18.500	697.9800	±	37.770	166.3000	±	49.420
19.000				179.2100	±	70.750
19.500	697.1900	±	40.660	187.3000	±	47.660
20.000	697.9700	±	40.700	195.1200	±	49.530

Table 27: Present evaluation for ^{56}Fe: cross sections and uncertainties

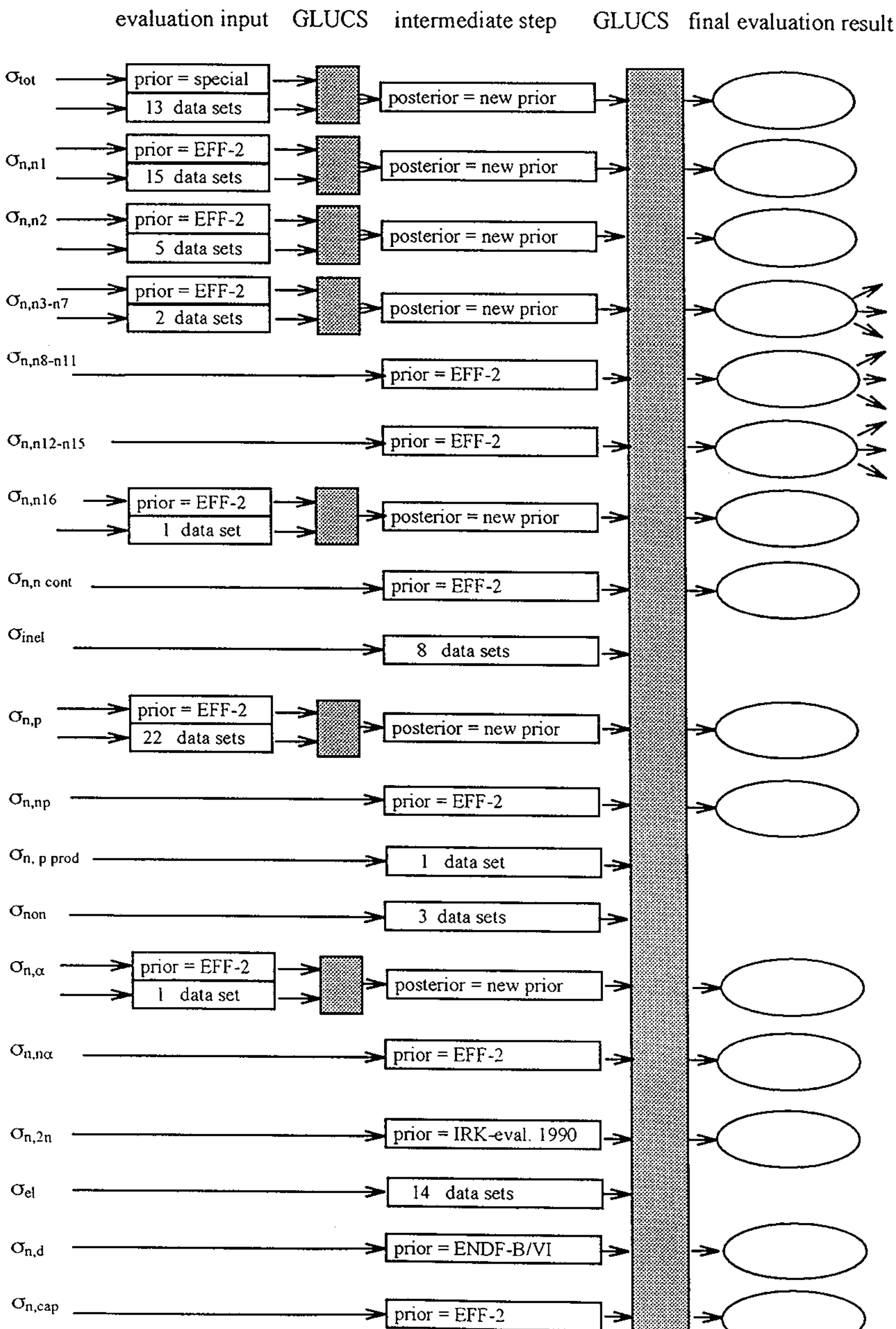
incid. Energy (MeV)	(n,nα), MT = 107 (millibarn)	(n,d), MT = 104 (millibarn)
7.747	0.0000 ± 0.000	
8.102		0.0000 ± 0.000
9.500		0.0100 ± 0.008
10.000		0.0672 ± 0.054
10.500		0.2797 ± 0.146
11.000	0.0004 ± 0.000	0.6717 ± 0.338
11.500	0.0059 ± 0.003	1.0607 ± 0.531
11.600	0.0078 ± 0.003	
11.700	0.0116 ± 0.005	
11.800	0.0113 ± 0.005	
11.900	0.0164 ± 0.007	
12.000	0.0180 ± 0.008	1.6127 ± 0.367
12.200	0.0267 ± 0.011	
12.400	0.0407 ± 0.017	
12.500		2.3728 ± 0.538
12.600	0.0579 ± 0.024	
12.800	0.1804 ± 0.073	
13.000	0.3100 ± 0.125	3.4268 ± 0.776
13.500	0.7737 ± 0.313	4.8161 ± 1.090
14.000	1.0425 ± 0.357	6.3499 ± 1.436
14.500	1.5261 ± 0.509	7.4513 ± 1.811
15.000	2.9646 ± 0.970	8.0615 ± 1.906
15.500	5.0956 ± 1.657	8.5916 ± 1.987
16.000	9.0658 ± 2.365	8.9790 ± 2.052
16.500	13.1530 ± 3.267	9.2481 ± 2.097
17.000	17.5800 ± 4.339	9.5101 ± 2.141
17.500	22.6200 ± 5.528	9.7477 ± 2.182
18.000	27.1150 ± 6.735	9.9746 ± 2.219
18.500	31.9550 ± 7.658	10.1620 ± 2.251
19.000	37.2790 ± 8.880	10.3480 ± 2.282
19.500	42.1710 ± 9.725	10.5090 ± 2.309
20.000	46.7350 ± 10.910	10.6800 ± 2.338

^{56}Fe evaluation-flow chart



21070053

^{52}Cr evaluation-flow chart



21070054

Figure 3

total cross section: EFF-2 and experimental data

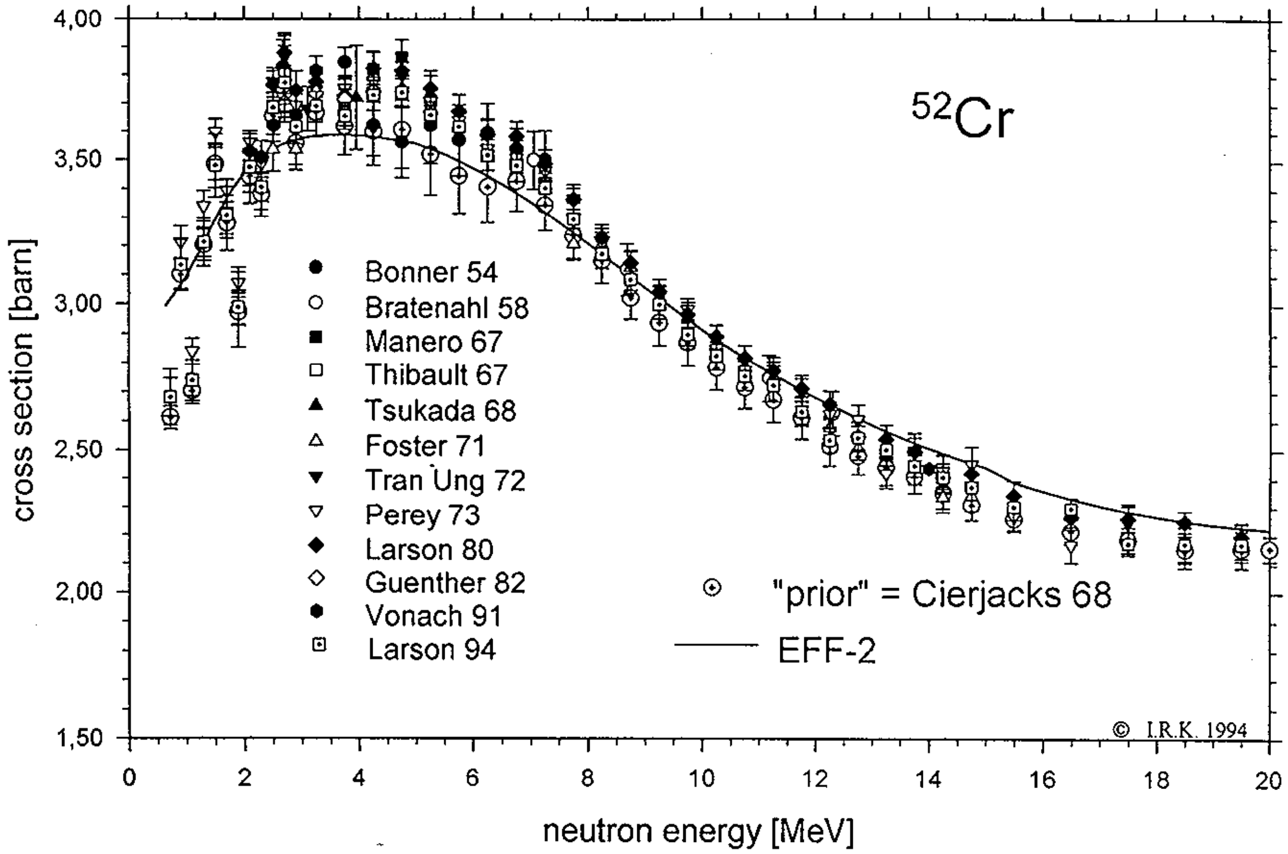


Figure 4

total cross section: Comparison of evaluations EFF-2 and IRK-1994

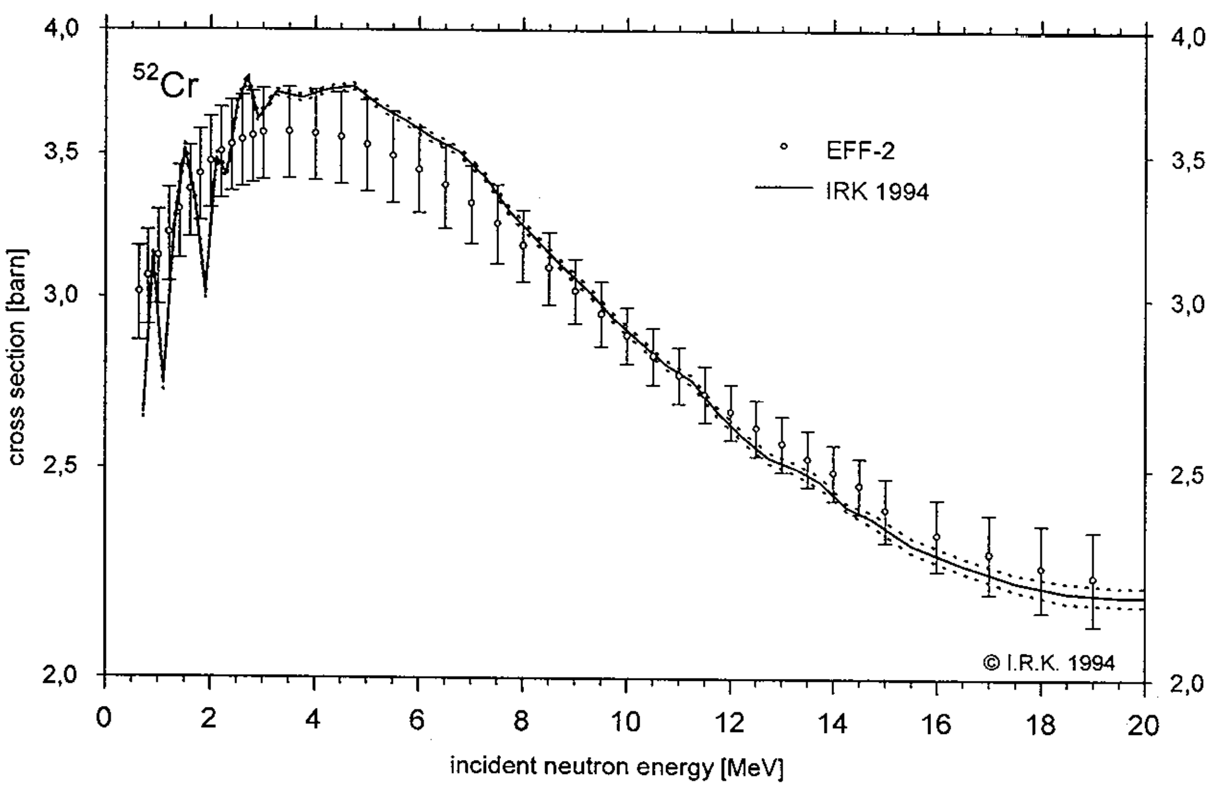


Figure 5

elastic cross section: EFF-2 and experimental data

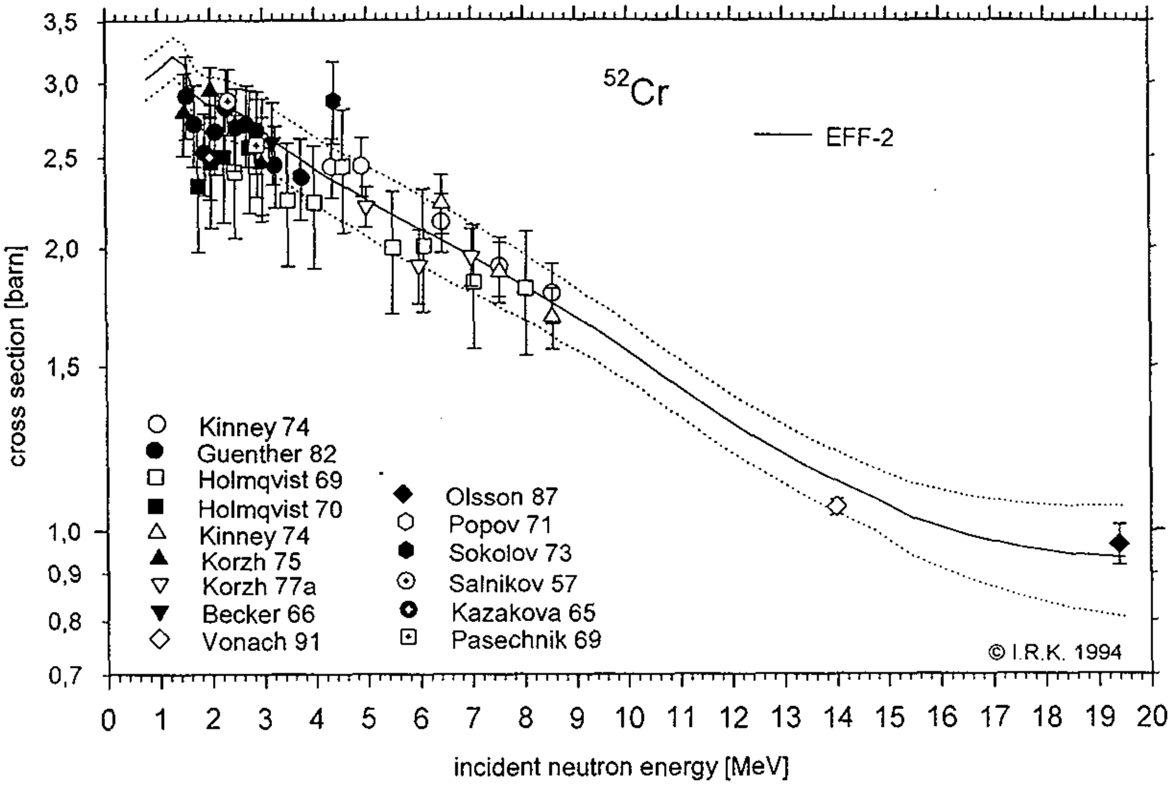


Figure 6

elastic cross section: EFF-2 and experimental data

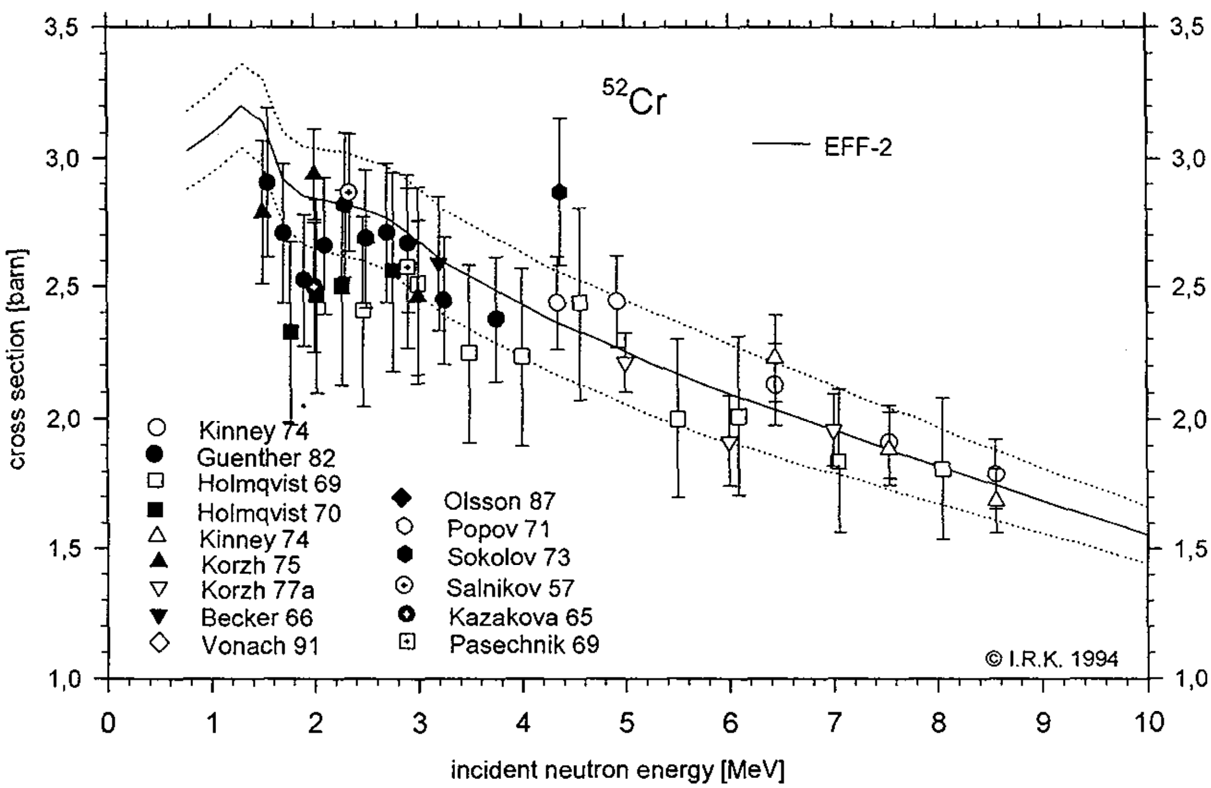
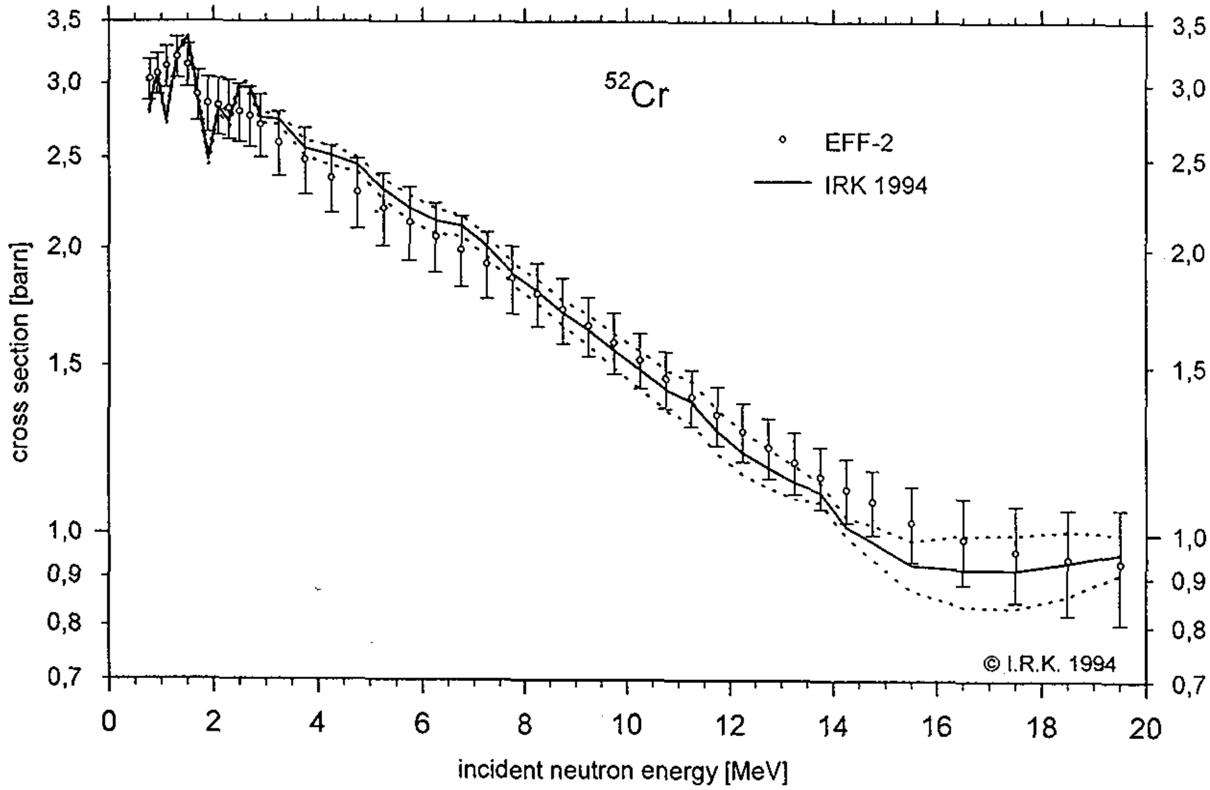


Figure 7

elastic cross section: Comparison of evaluations EFF-2 and IRK-1994



21070057

Figure 8

nonelastic cross section: EFF-2 and experimental data

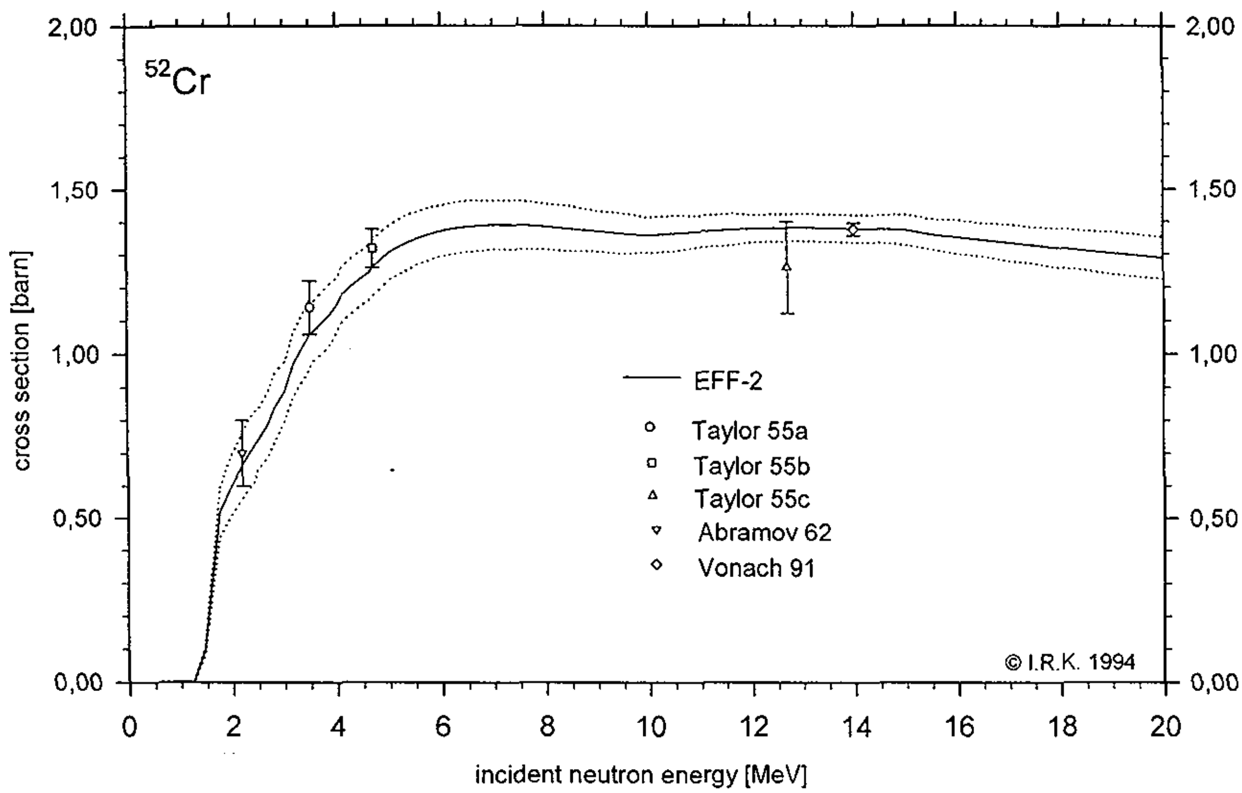


Figure 9

nonelastic cross section: Comparison of evaluations EFF-2 and IRK-1994

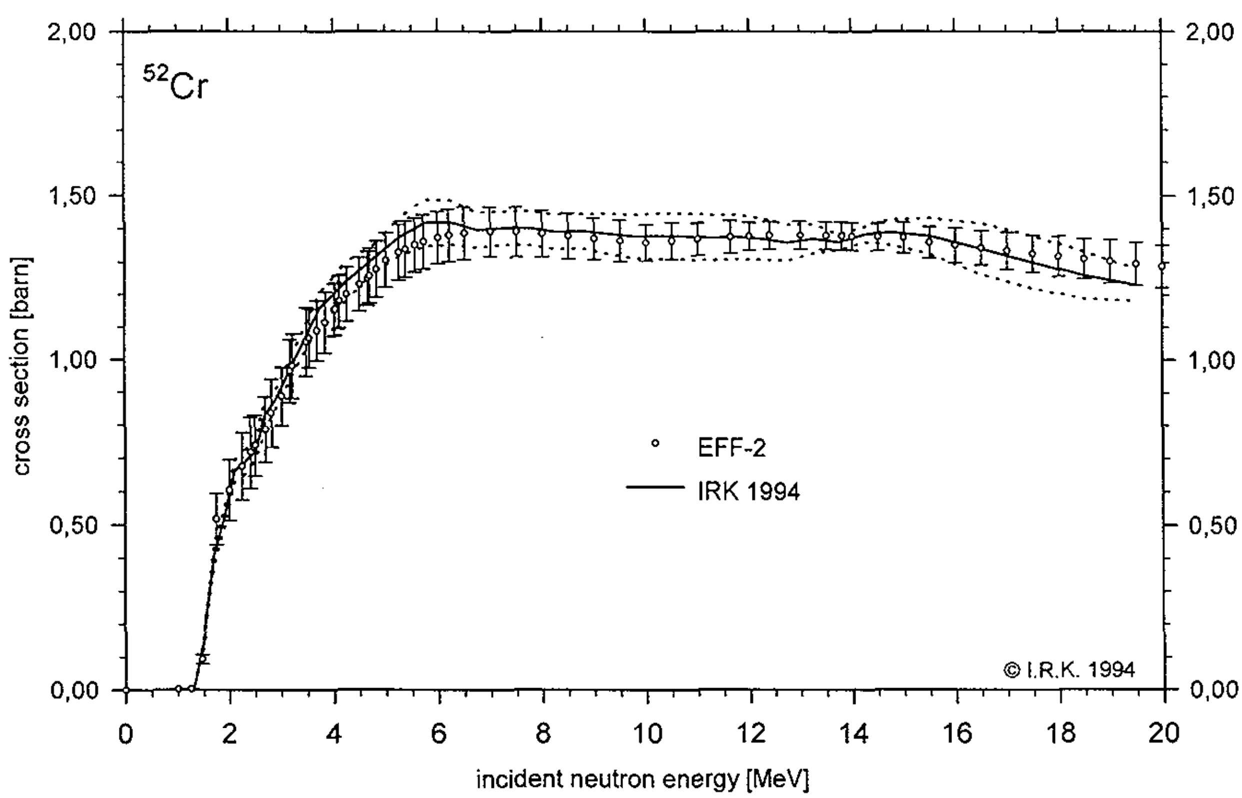


Figure 10

total inelastic cross section: EFF-2 and experimental data

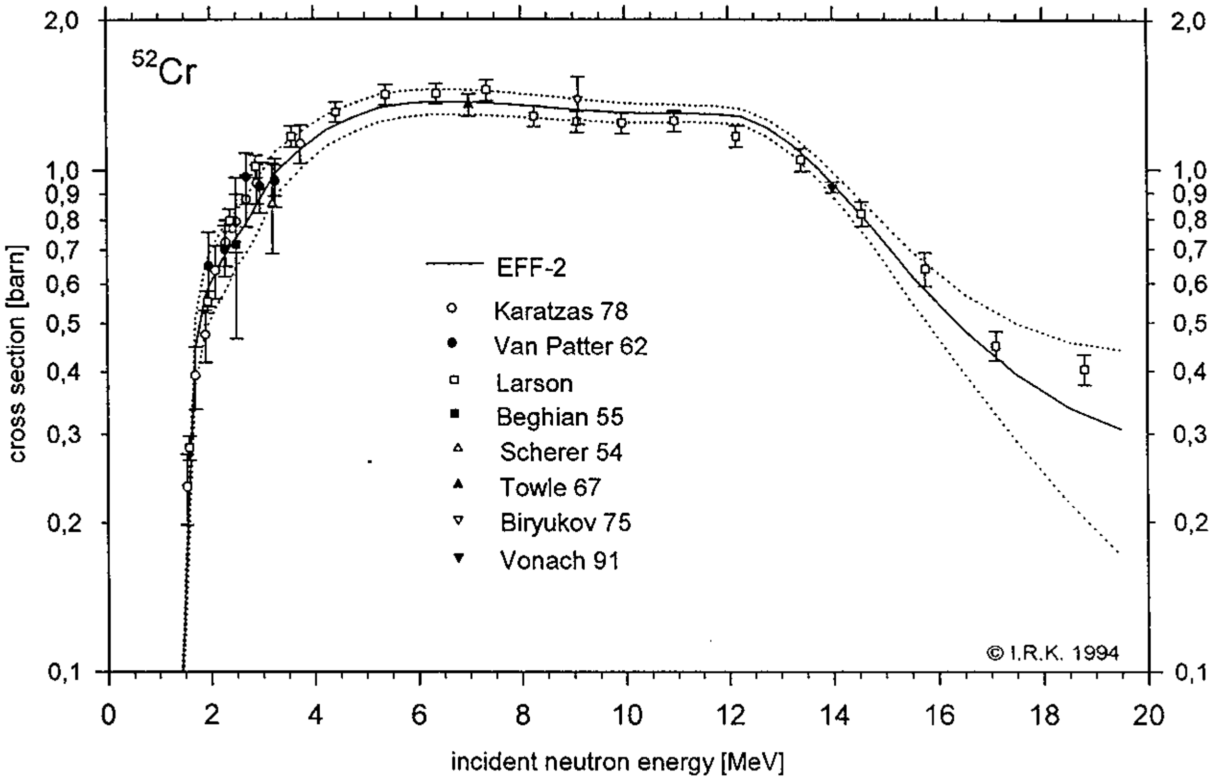


Figure 11

total inelastic cross section: Comparison of evaluations EFF-2 and IRK-1994

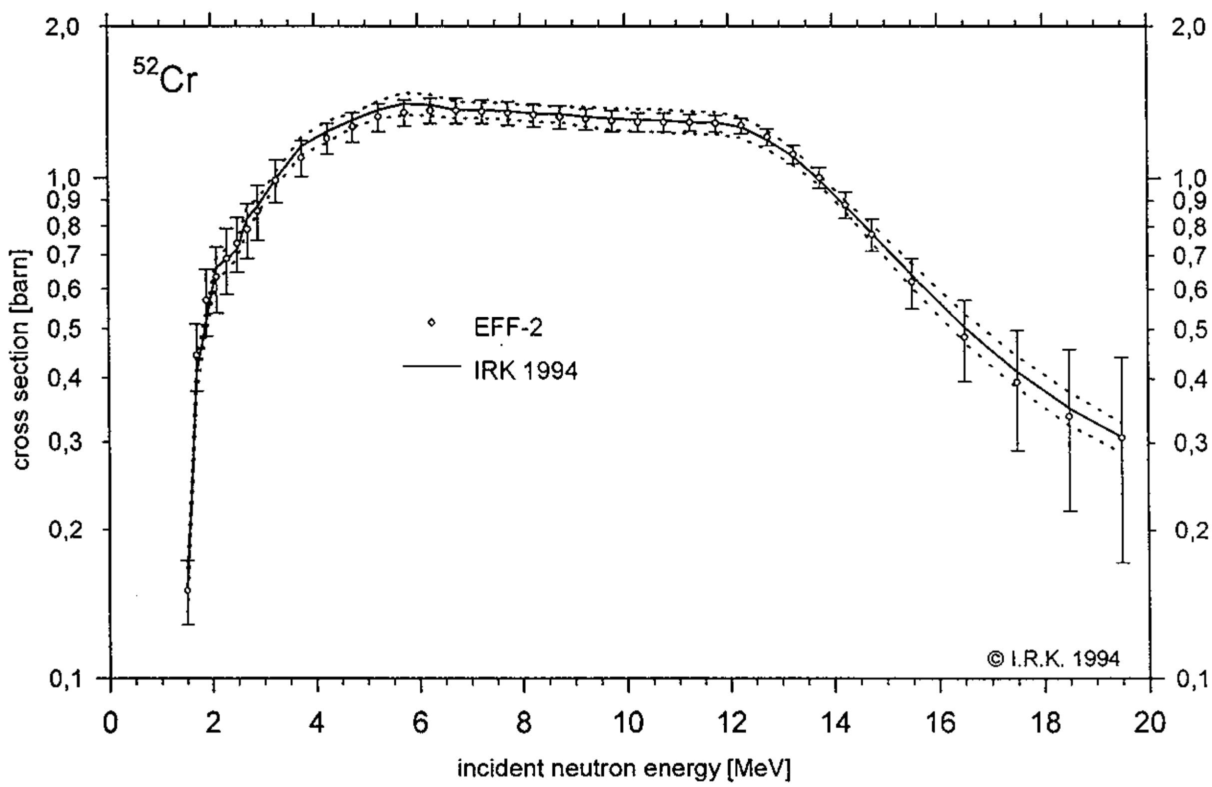


Figure 12

(n,n$_1$) cross section: EFF-2 and experimental data

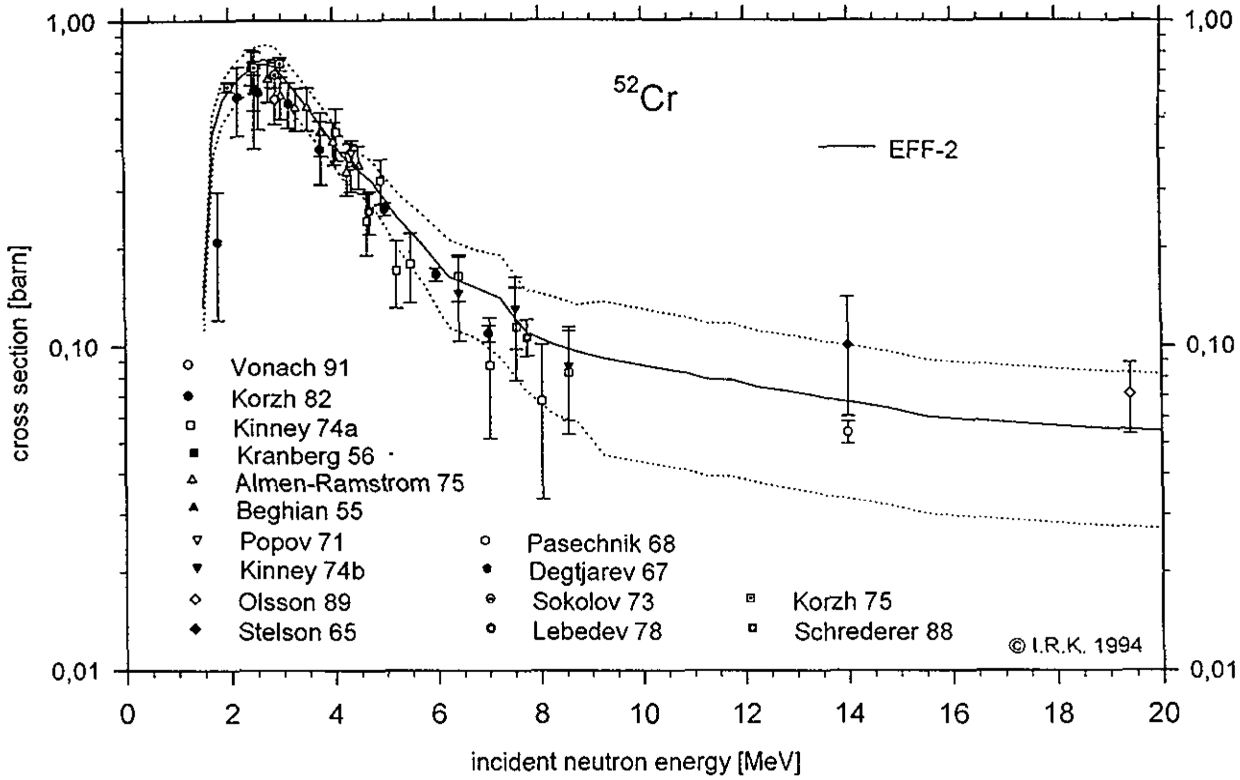
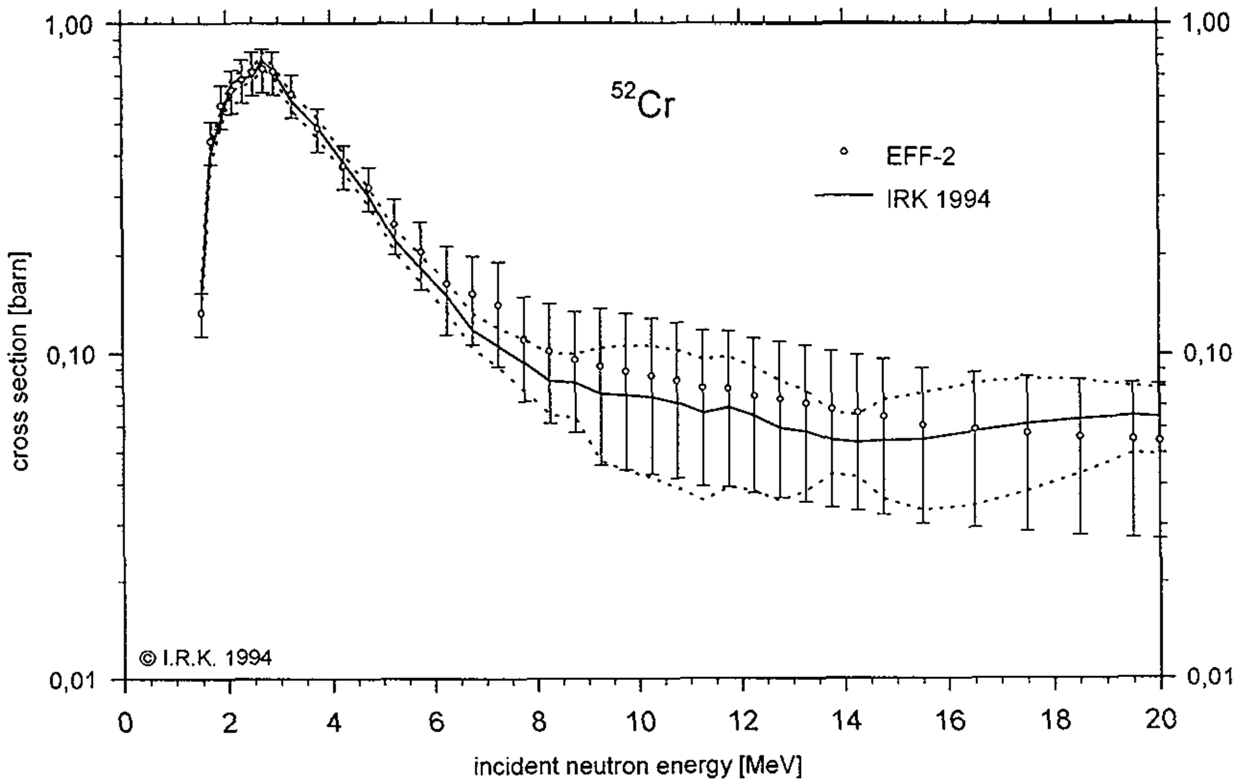


Figure 13

(n,n$_1$) cross section: Comparison of evaluations EFF-2 and IRK-1994



21070060

Figure 14

(n,n_2) cross section: EFF-2 and experimental data

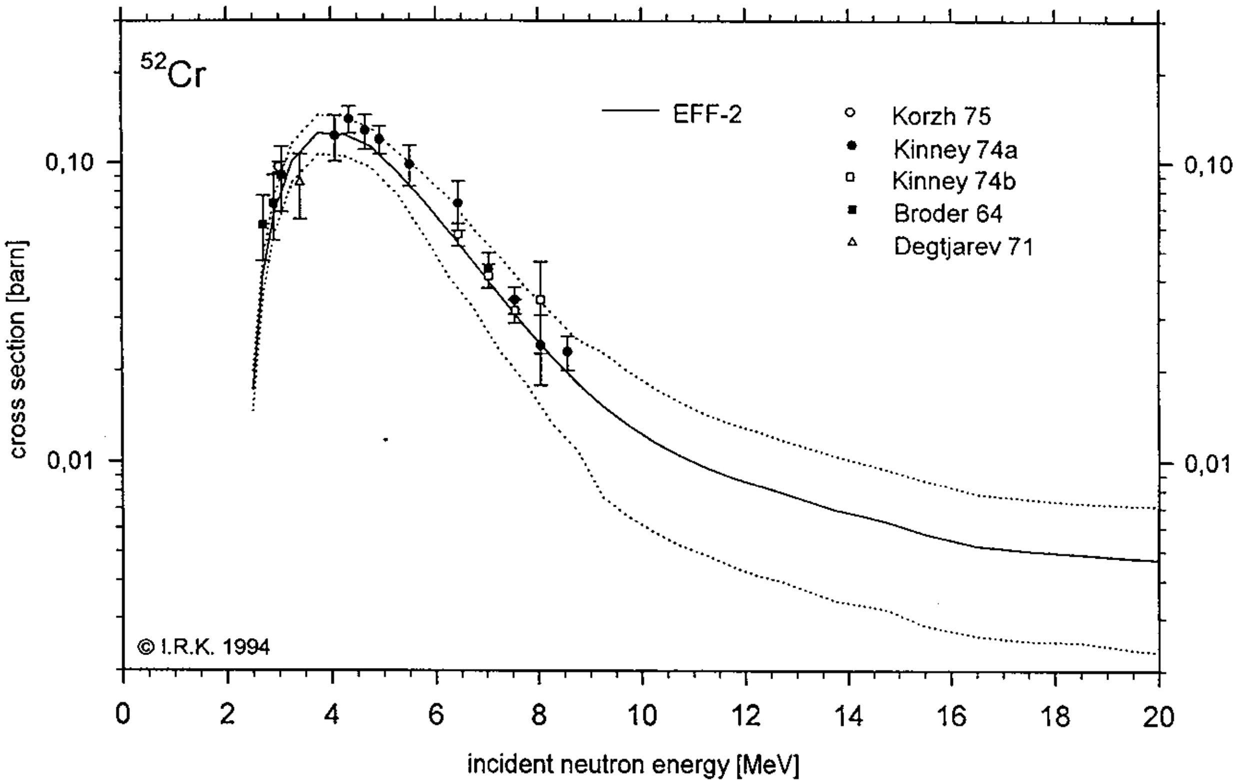
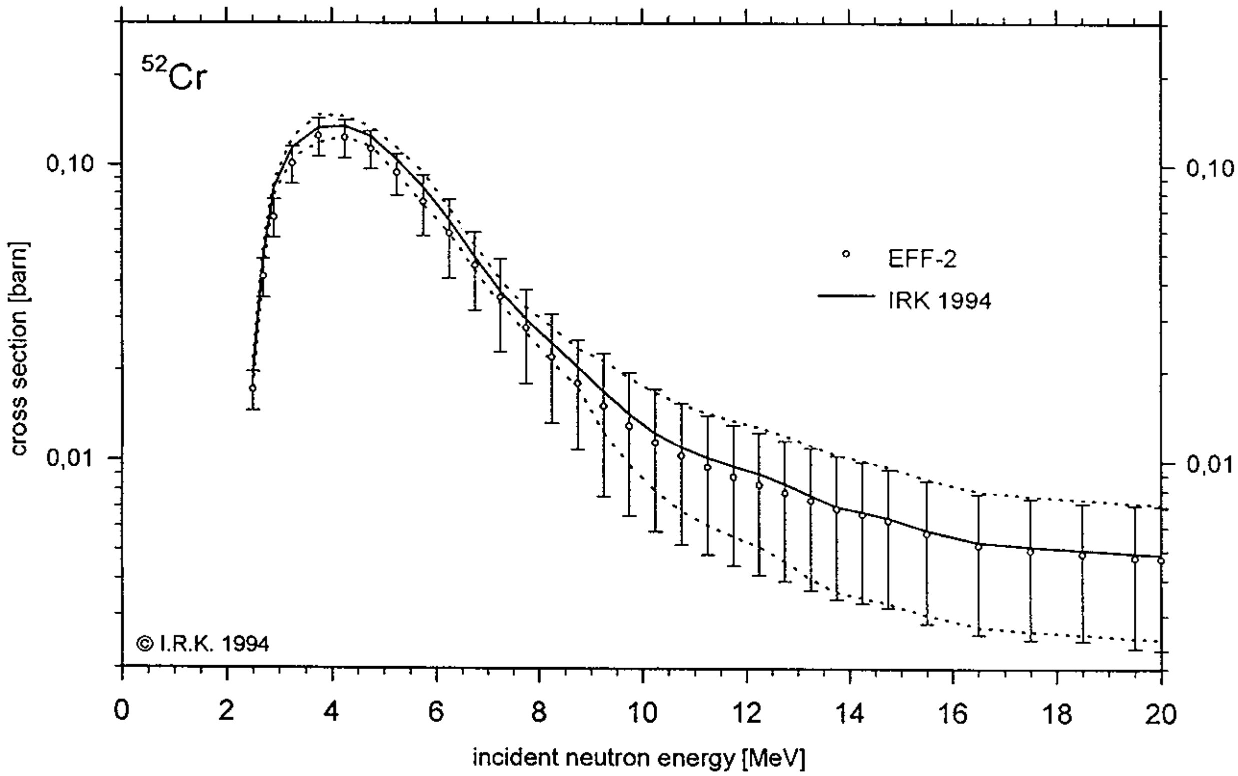


Figure 15

(n,n_2) cross section: Comparison of evaluations EFF-2 and IRK-1994



21070061

Figure 16

(n,n_{3-7}) cross section: EFF-2 and experimental data

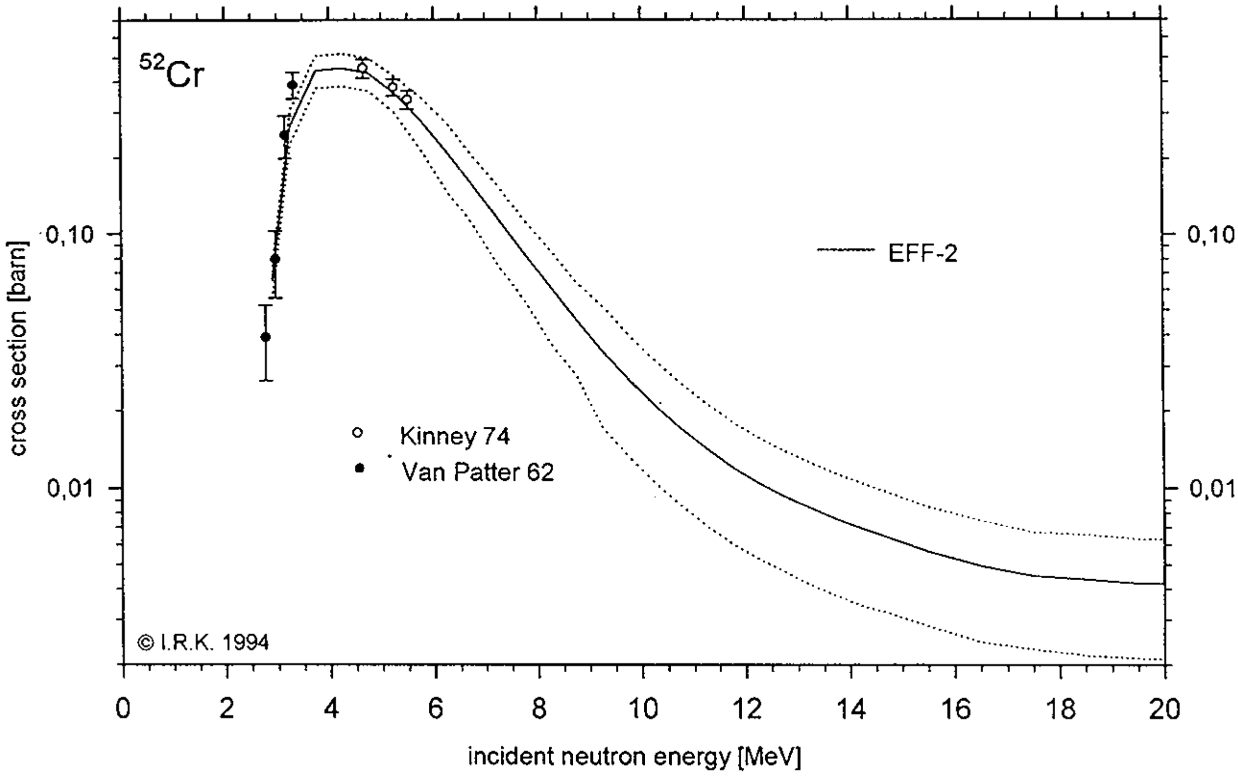
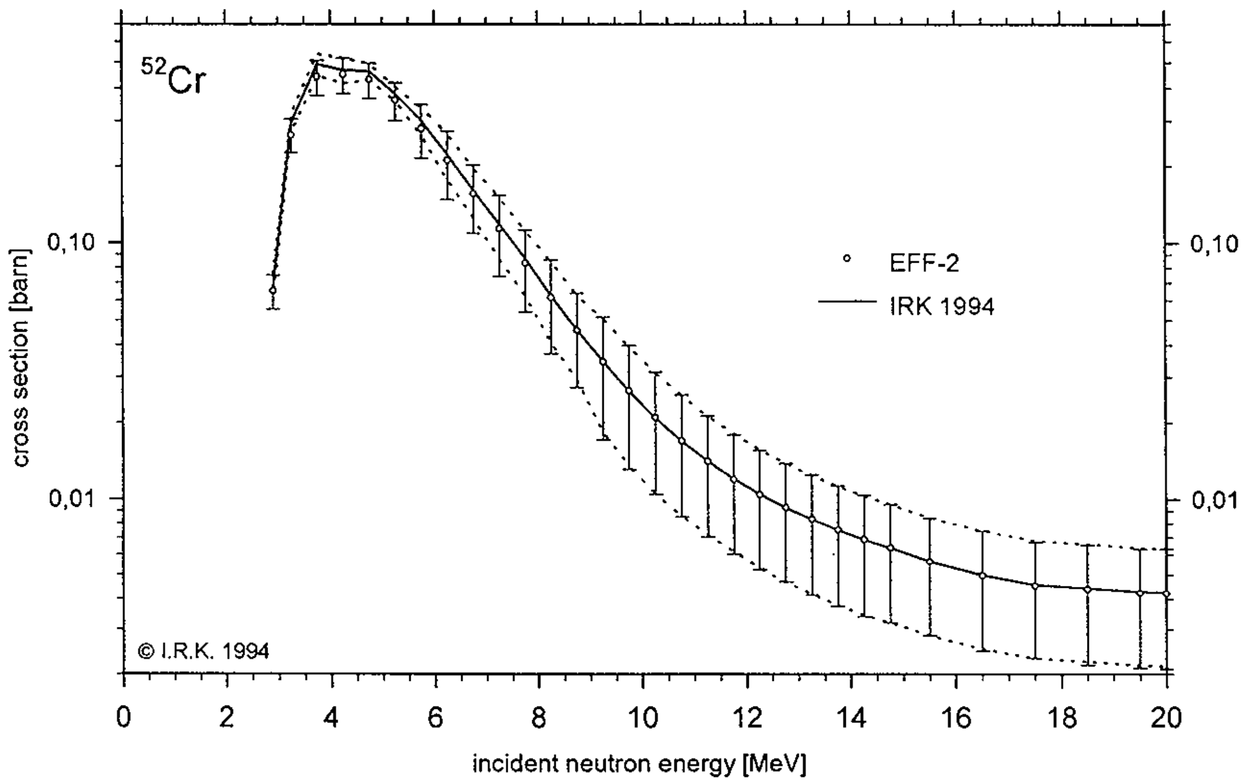


Figure 17

(n,n_{3-7}) cross section: Comparison of evaluations EFF-2 and IRK-1994



21070062

Figure 18

(n,p) cross section: EFF-2 and experimental data

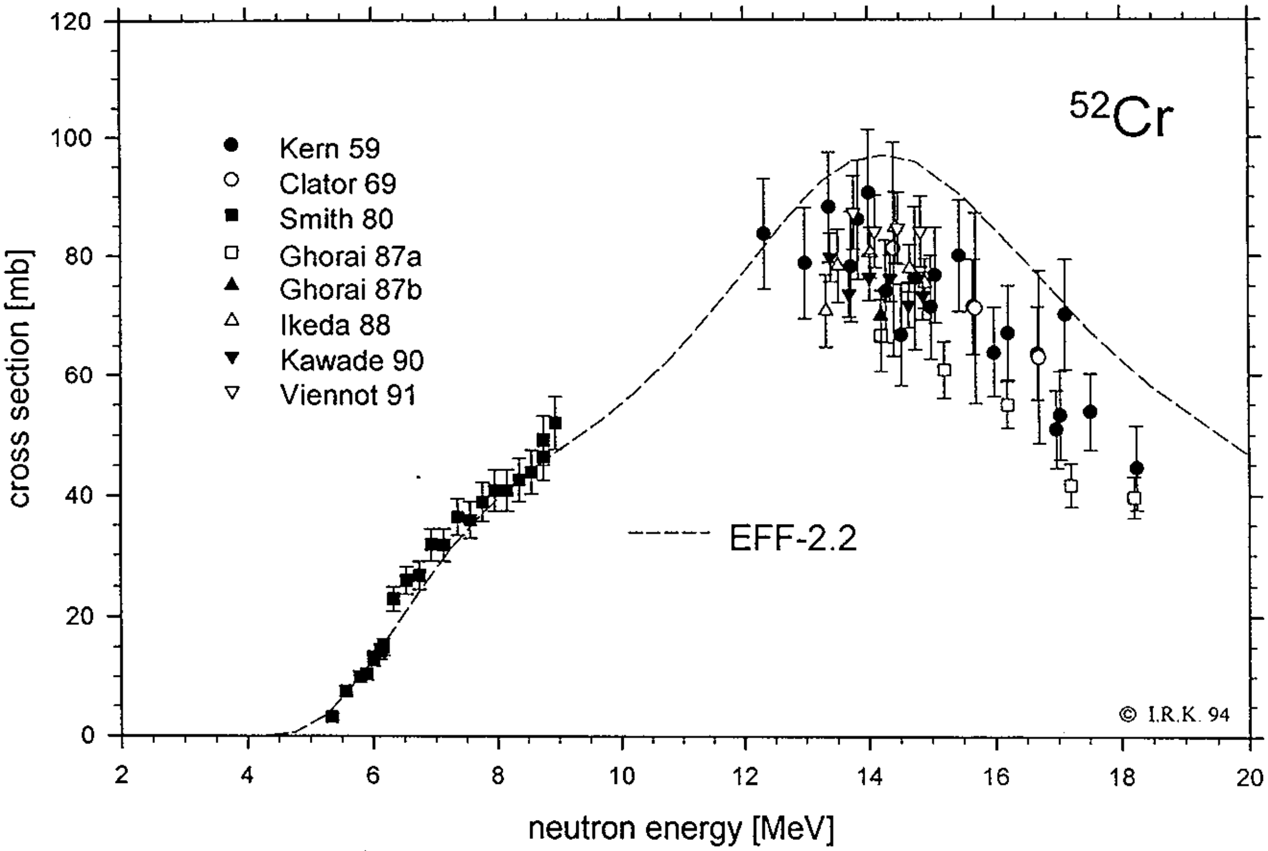
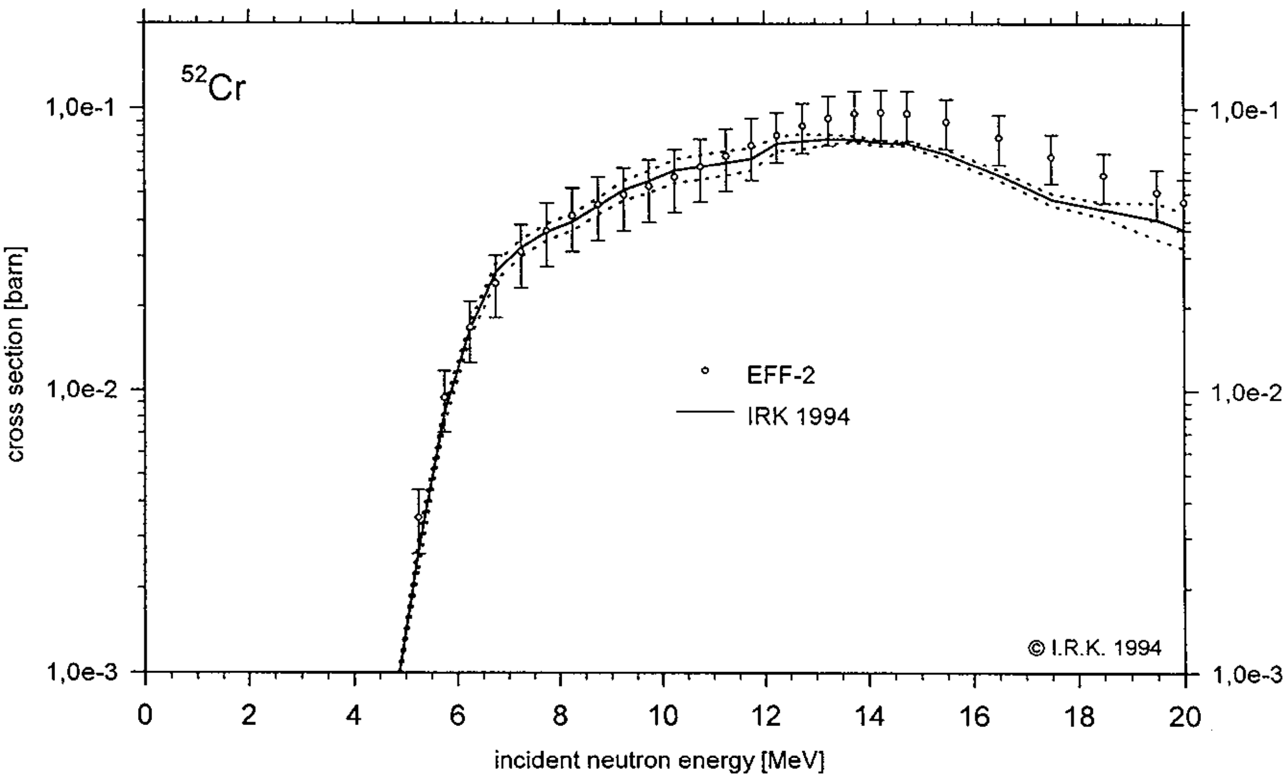


Figure 19

(n,p) cross section: Comparison of evaluations EFF-2 and IRK-1994



21070063

Figure 20

(n,2n) cross section: Comparison of evaluations EFF-2 and IRK-1994

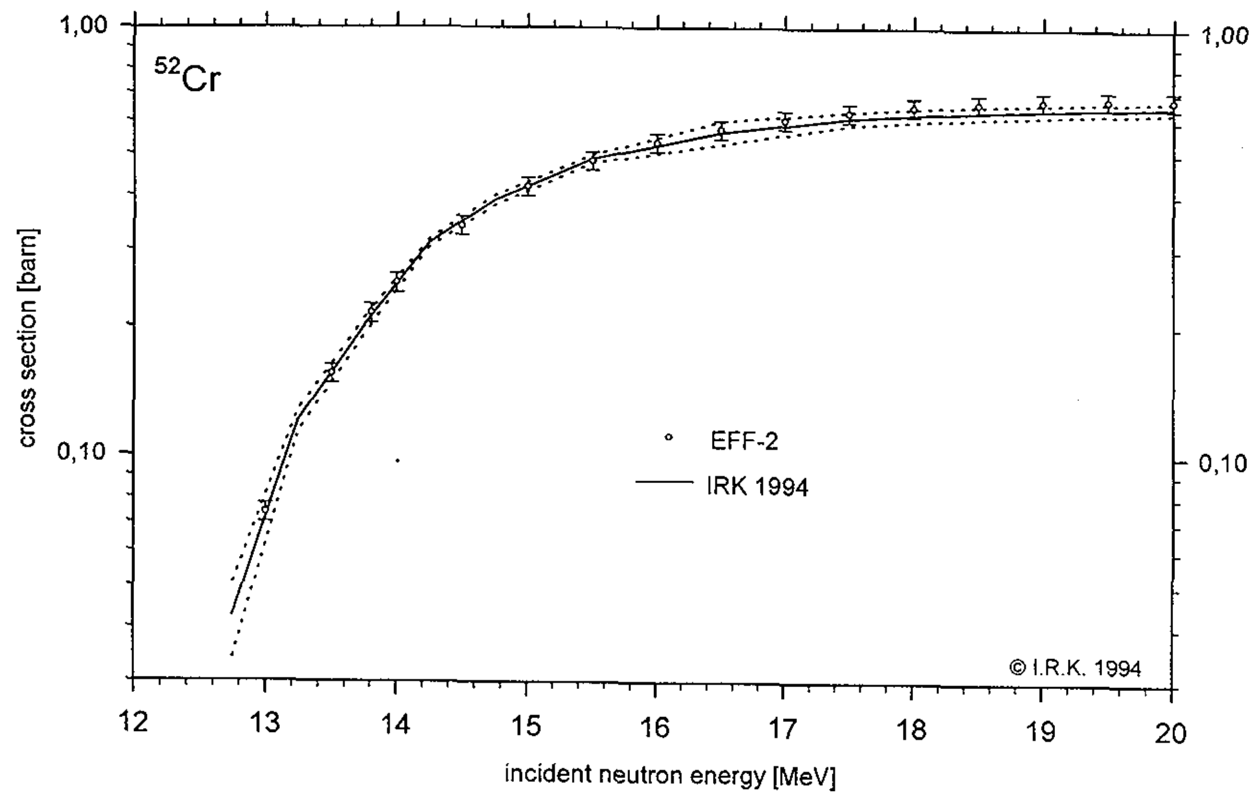


Figure 21

(n,α) cross section: Comparison of evaluations EFF-2 and IRK-1994

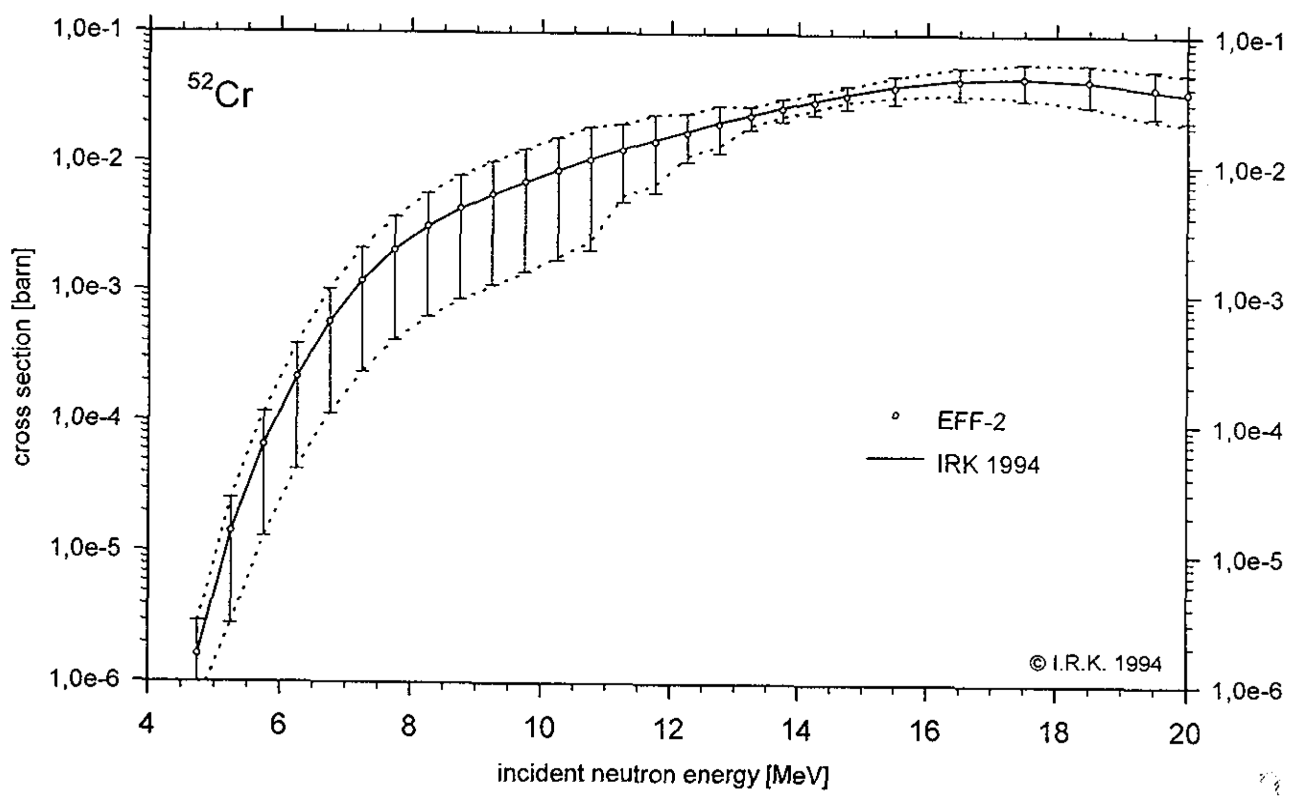


Figure 22

(n,np) cross section: Comparison of evaluations EFF-2 and IRK-1994

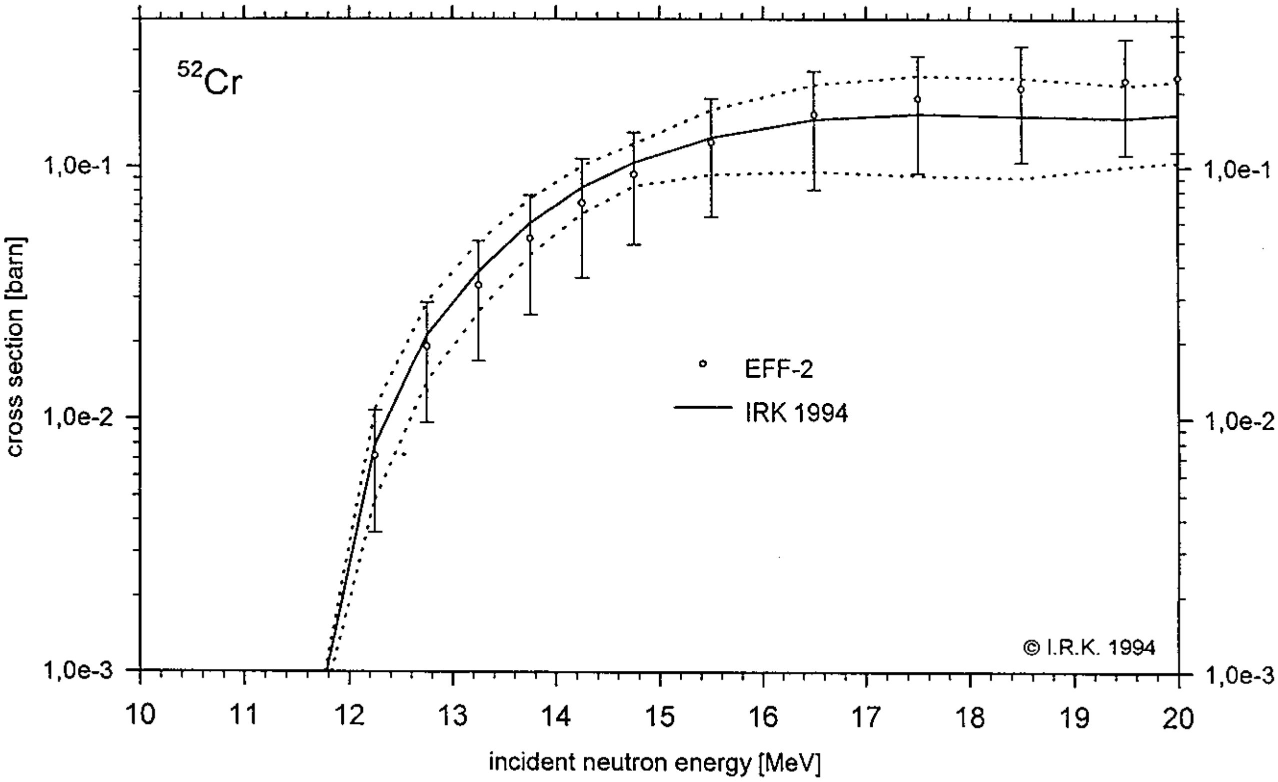
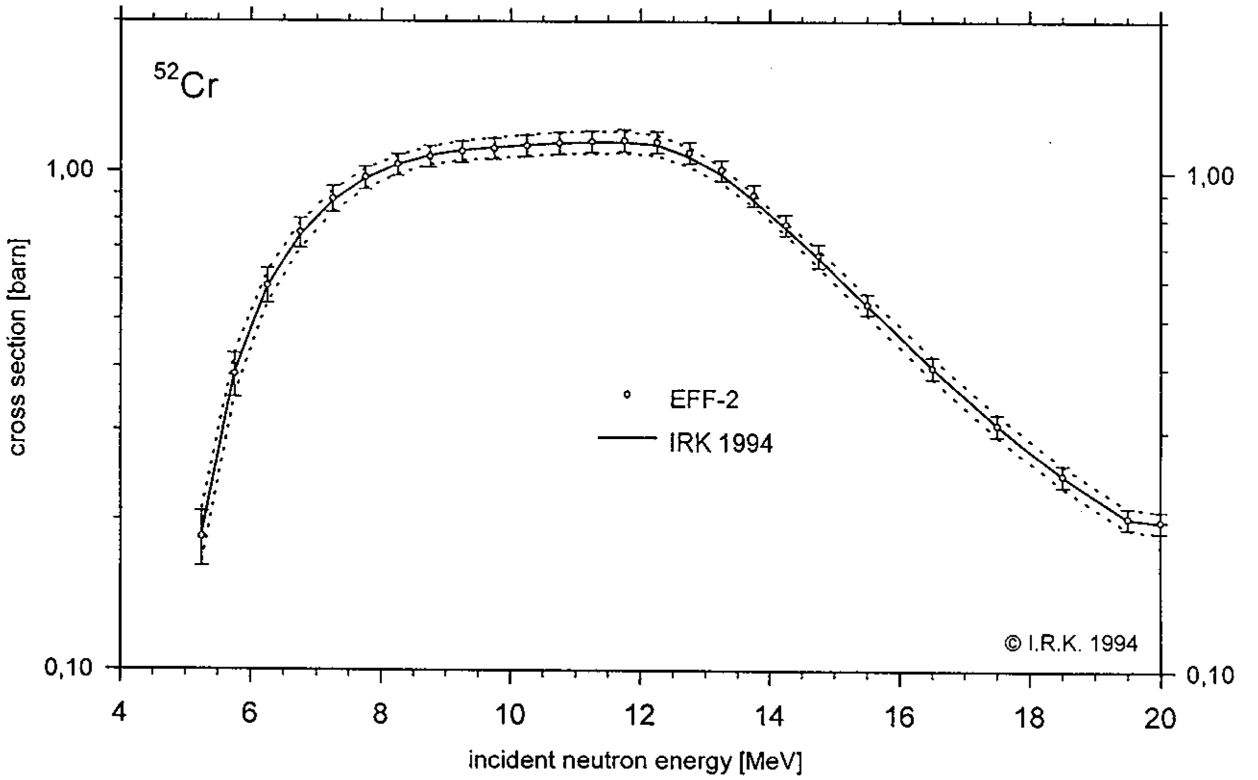


Figure 23

(n,n_{cont}) cross section: Comparison of evaluations EFF-2 and IRK-1994



21070065

Figure 24

52Cr (total) correlation matrix

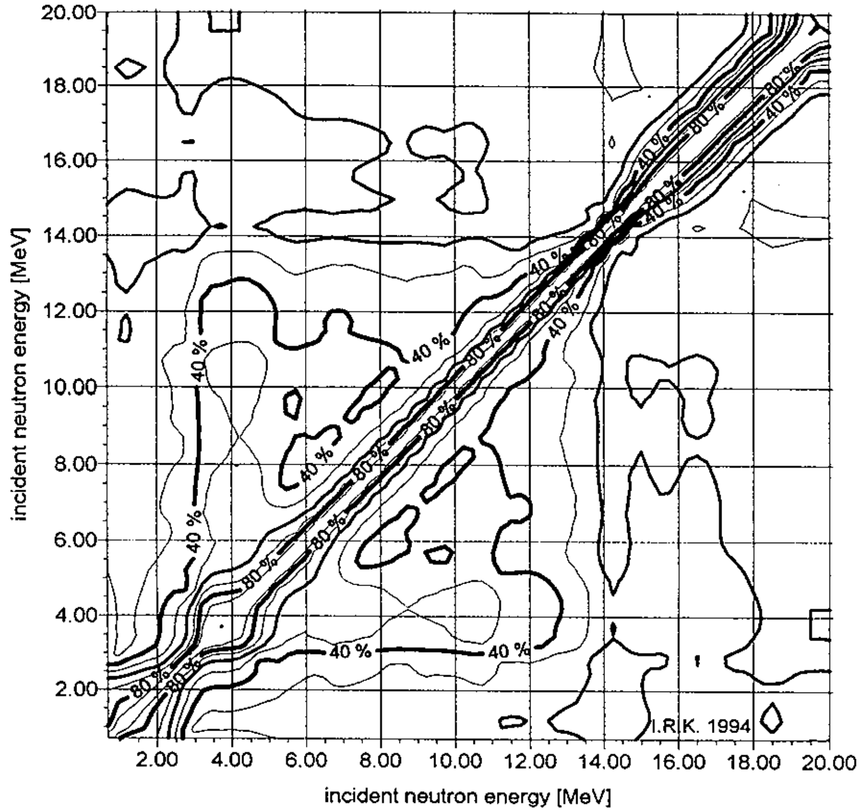
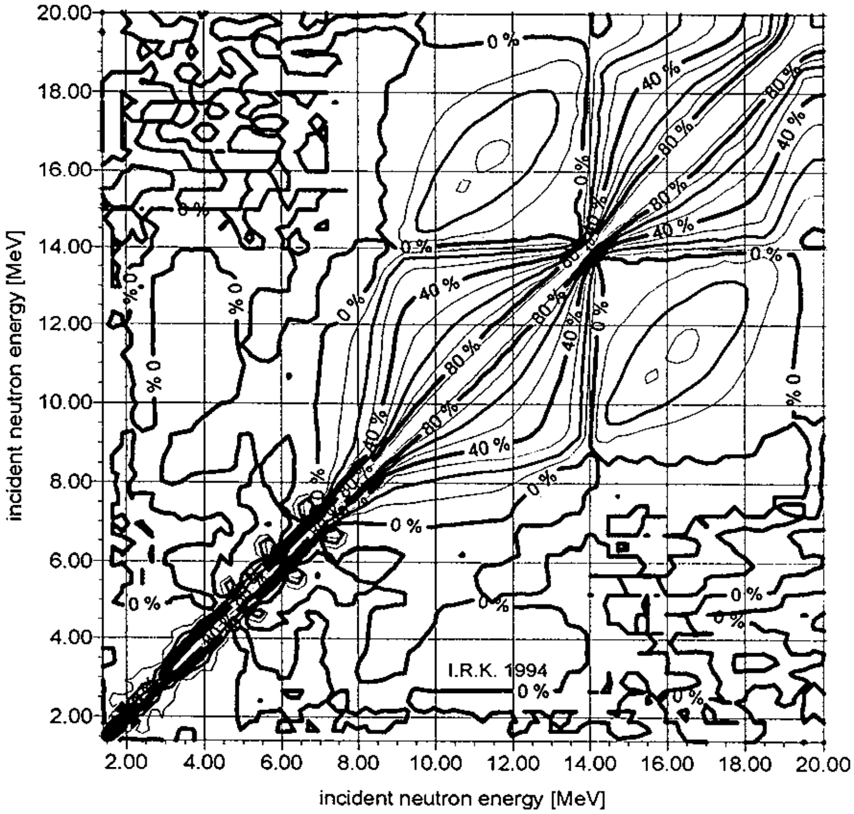


Figure 25

52Cr (n,n1) correlation matrix



21070066

Figure 26

52Cr (n,2n) correlation matrix

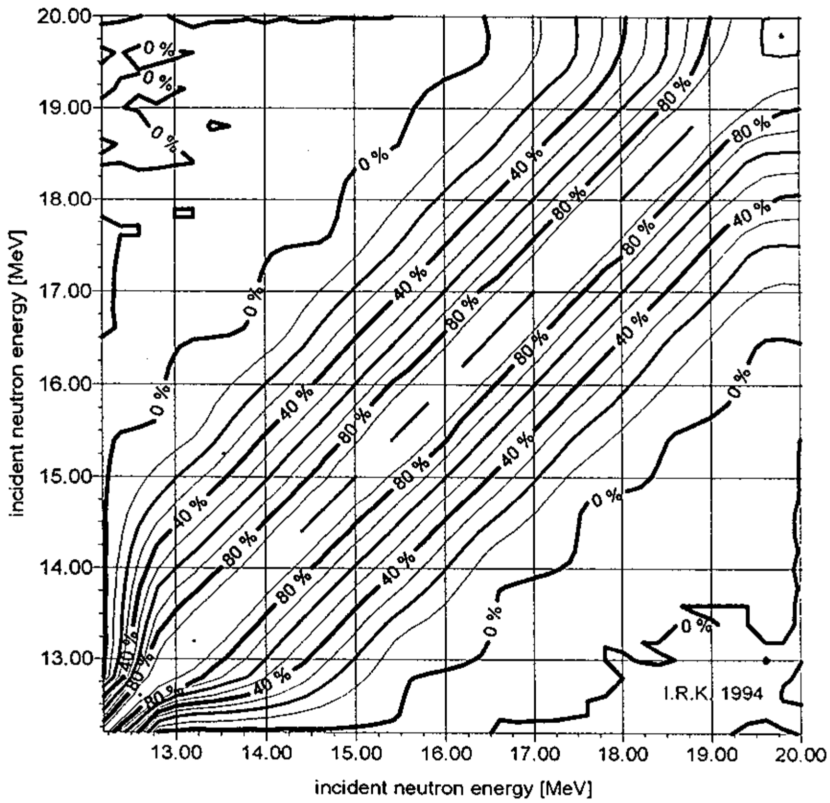
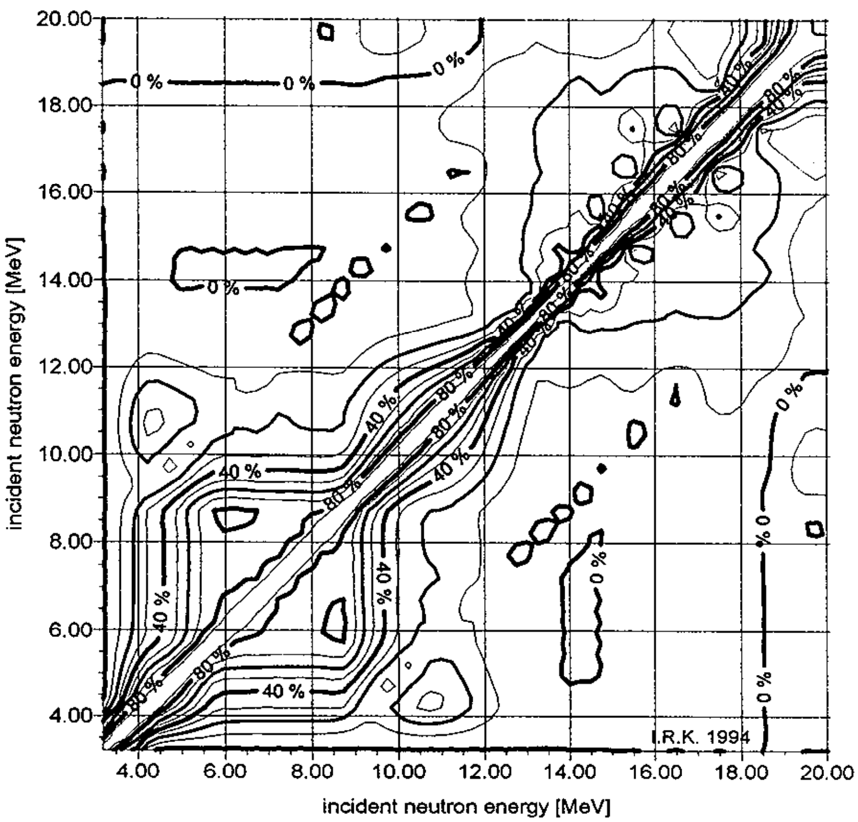


Figure 27

52Cr (n,p) correlation matrix



21070067

Figure 28

total cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI

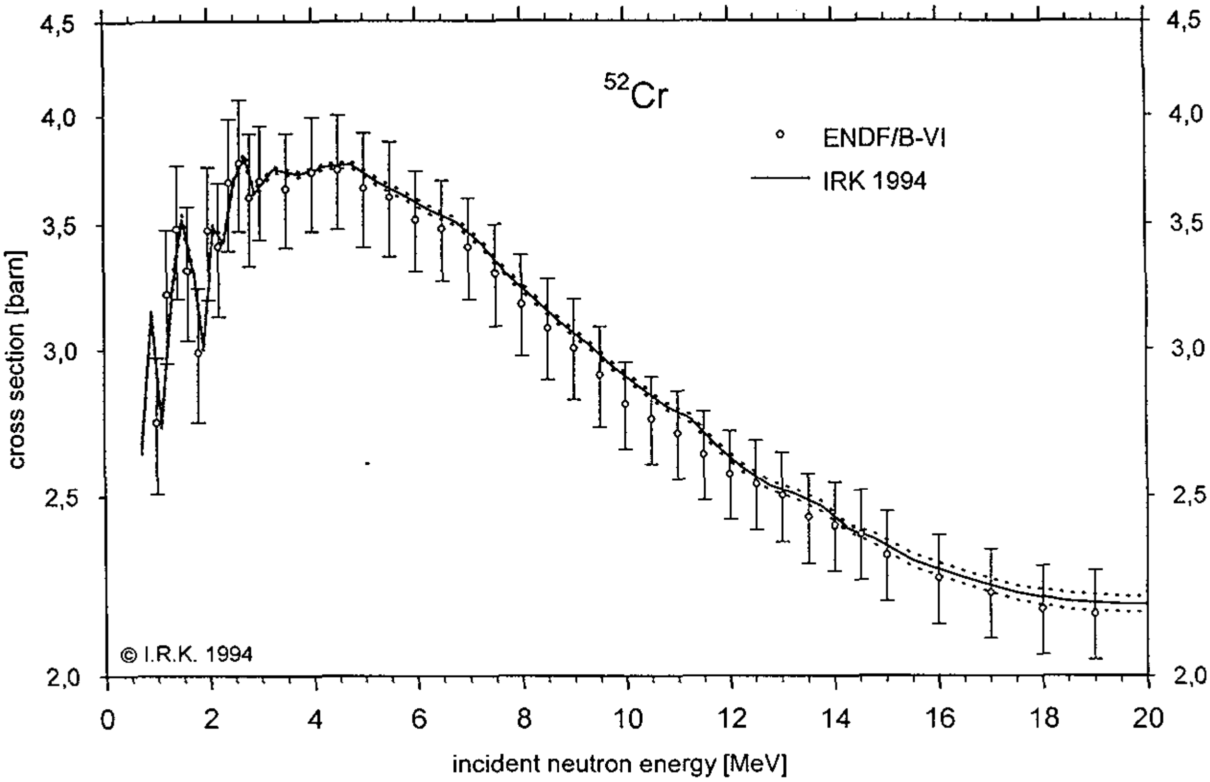
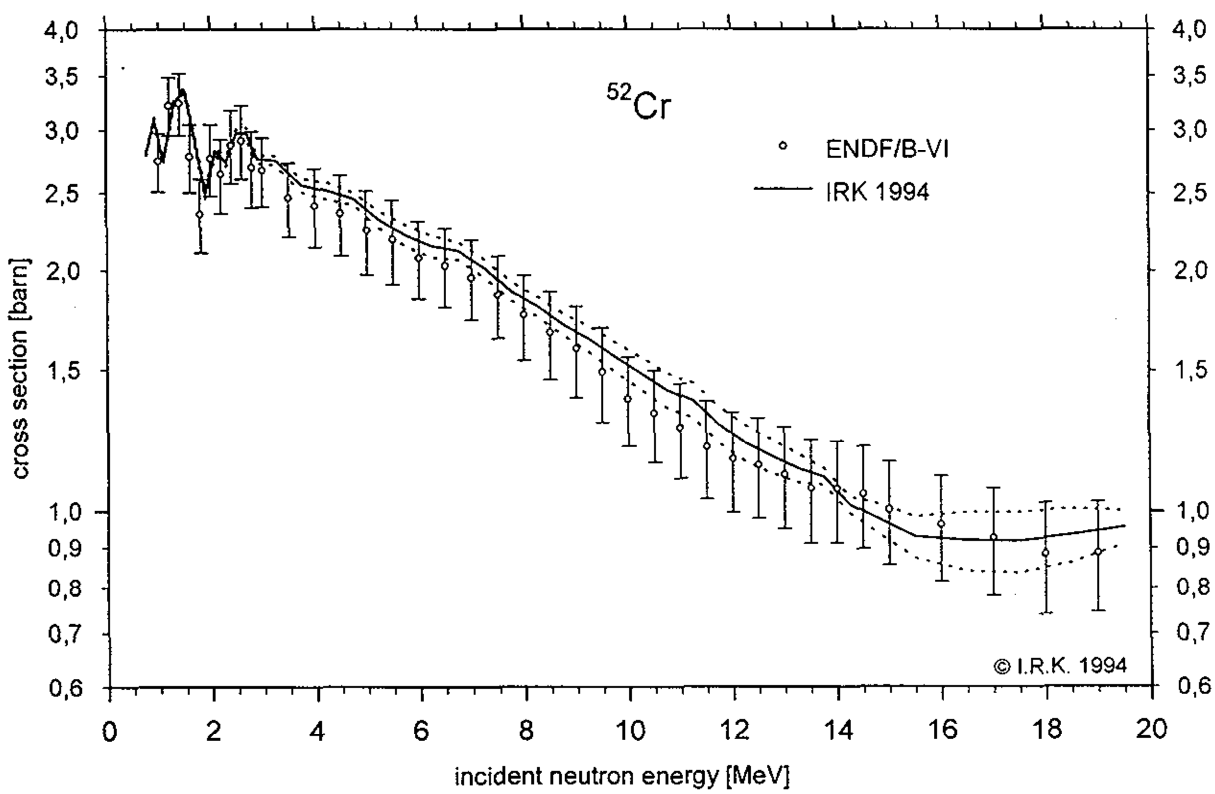


Figure 29

elastic cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI



21070068

Figure 30

nonelastic cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI

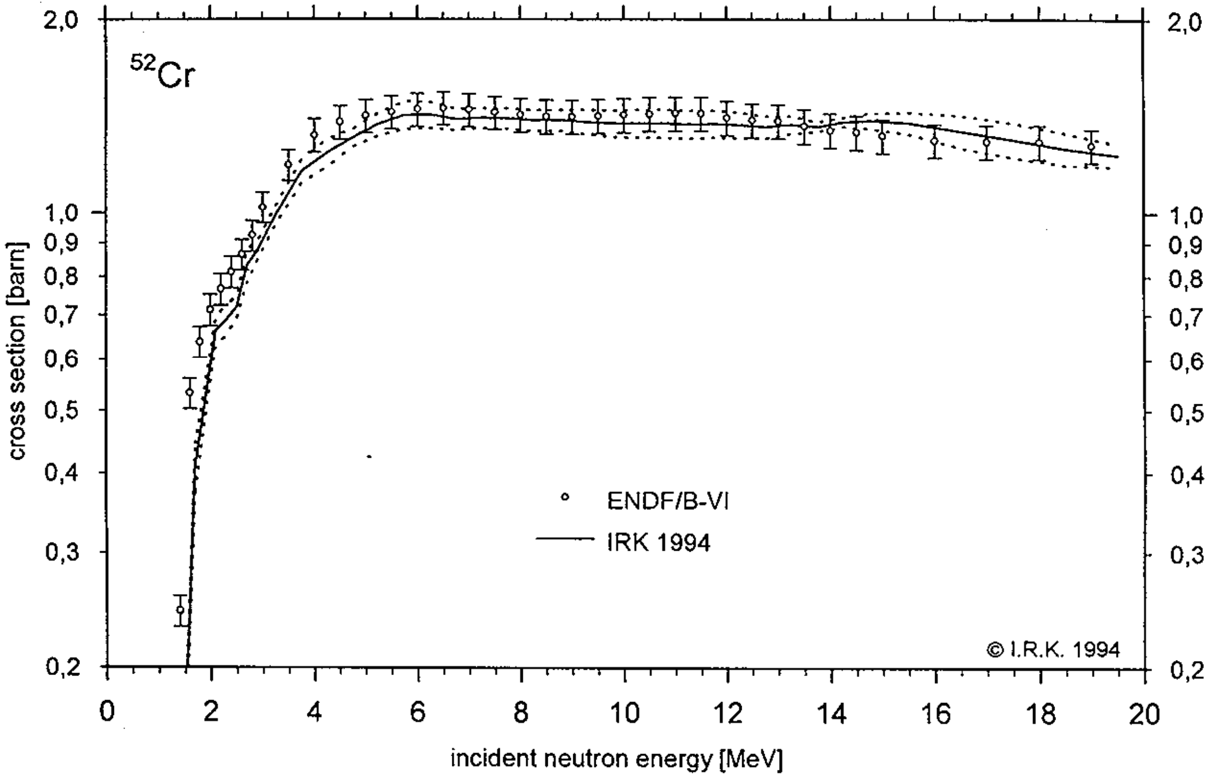
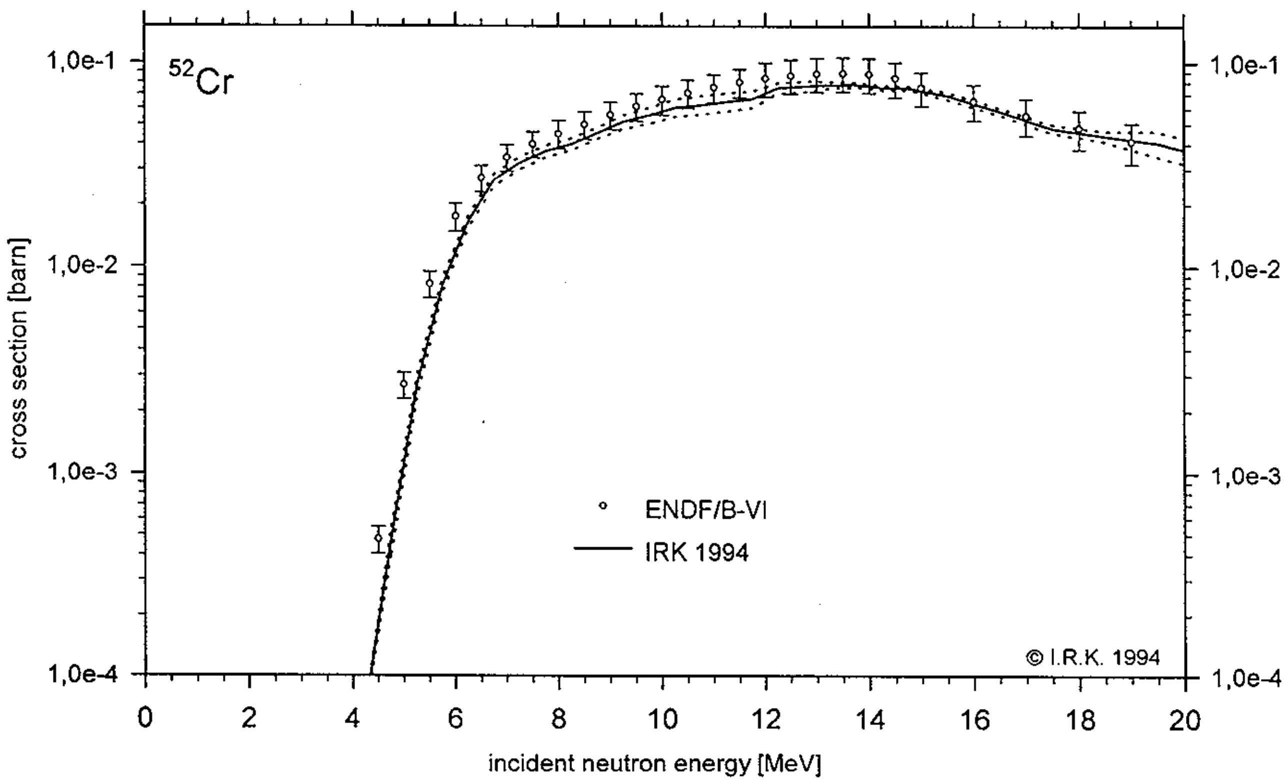


Figure 31

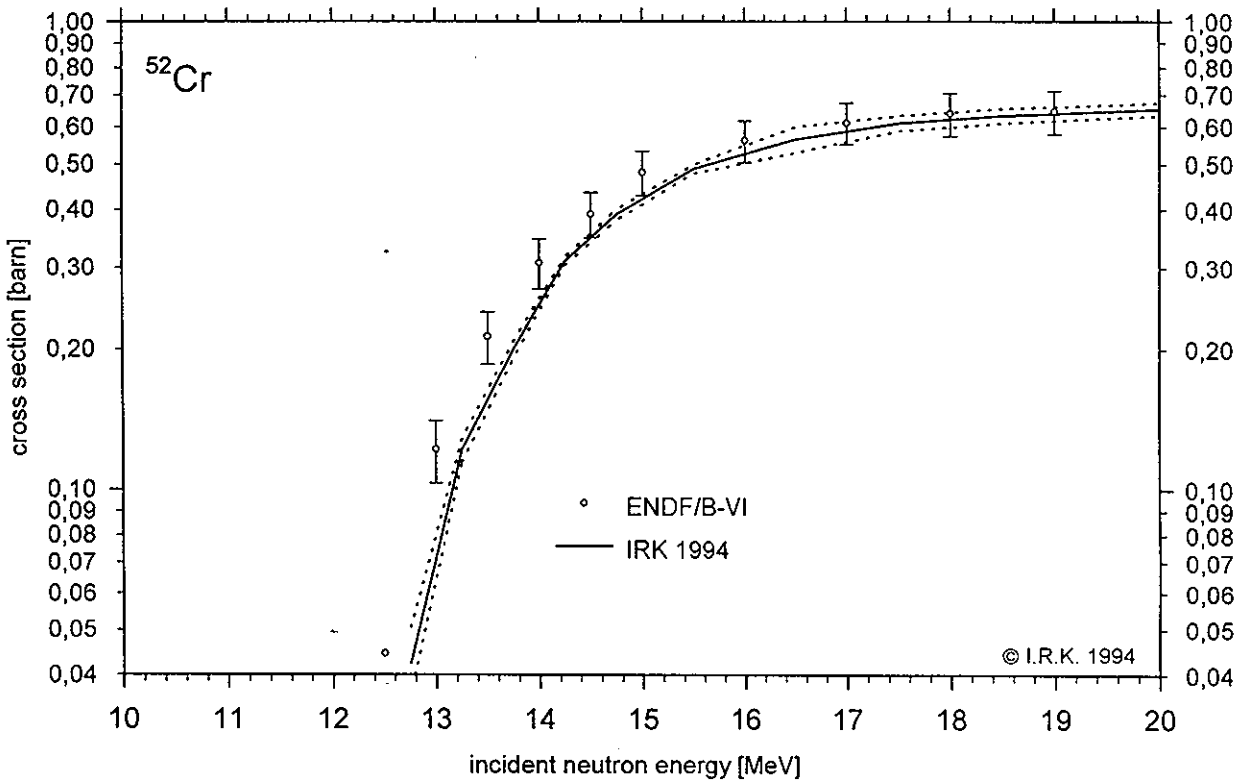
(n,p) cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI



21070069

Figure 32

(n,2n) cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI



2107007(

Figure 33

total cross section: I.R.K. evaluation 1992 & new (corrected) data

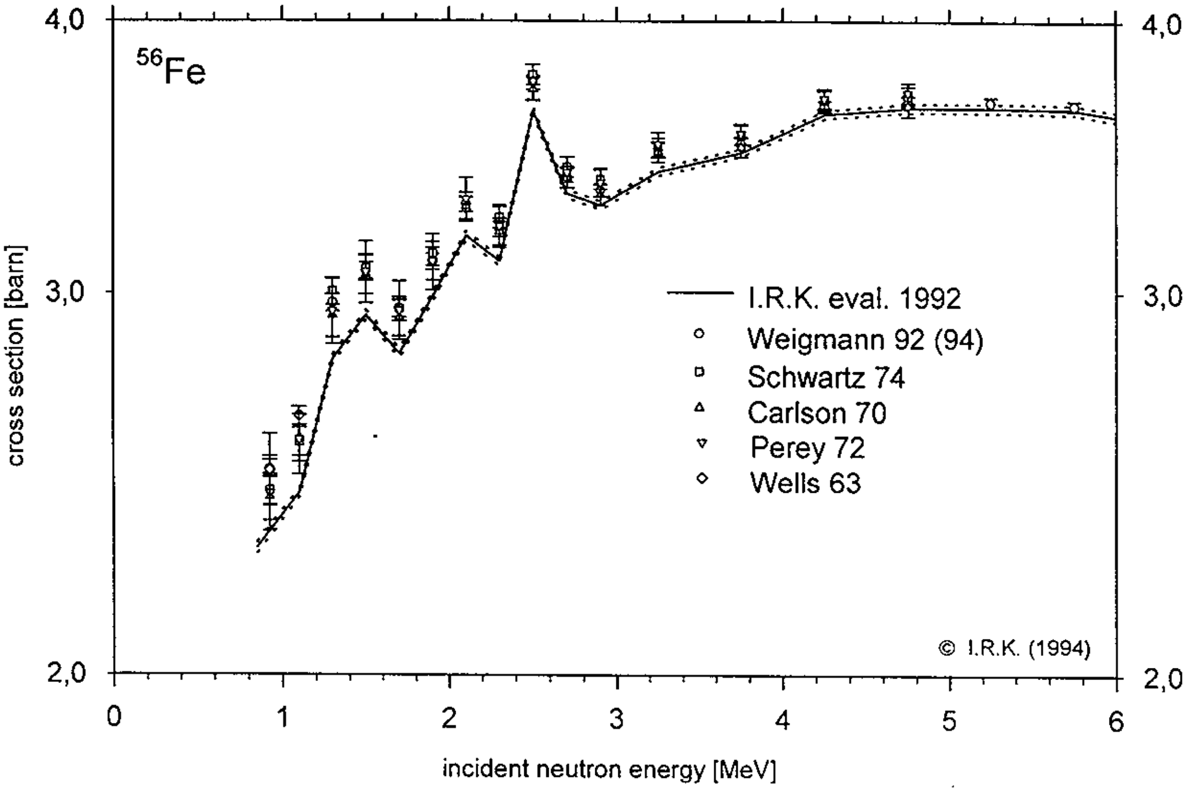


Figure 34

total cross section: I.R.K. evaluation 1992 & new (corrected) data

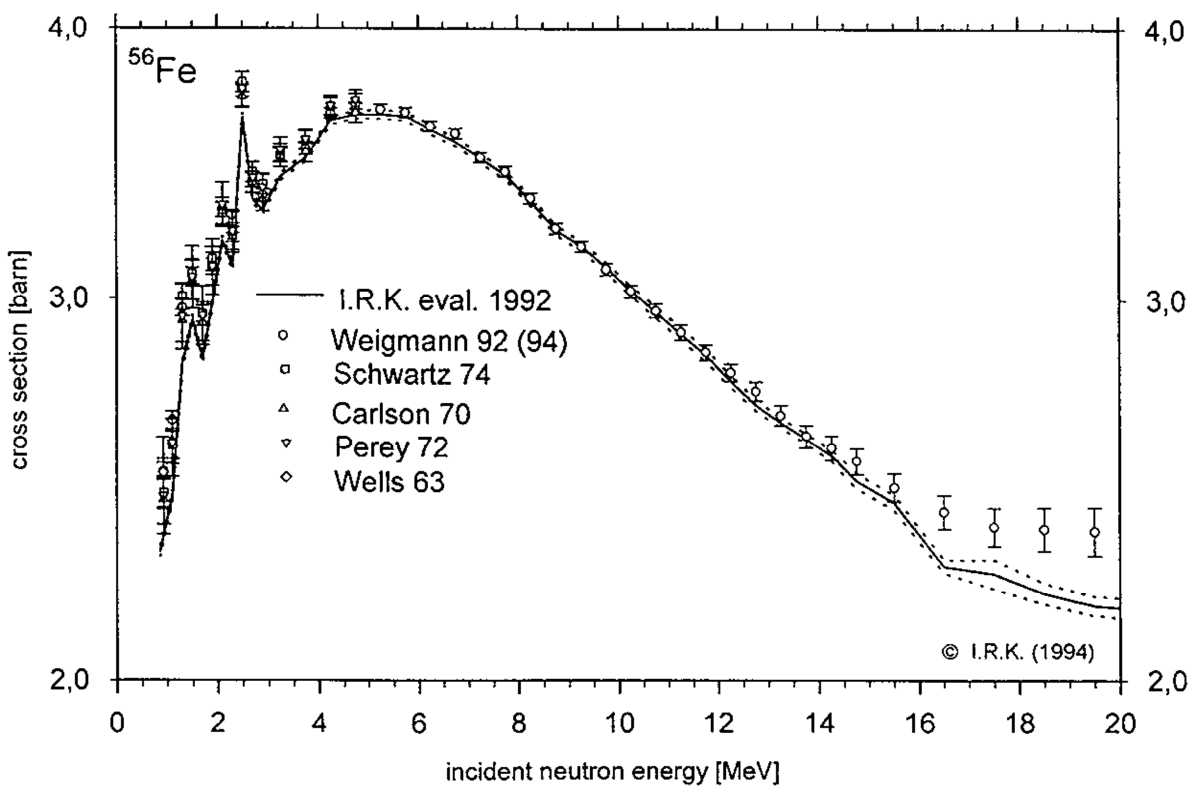
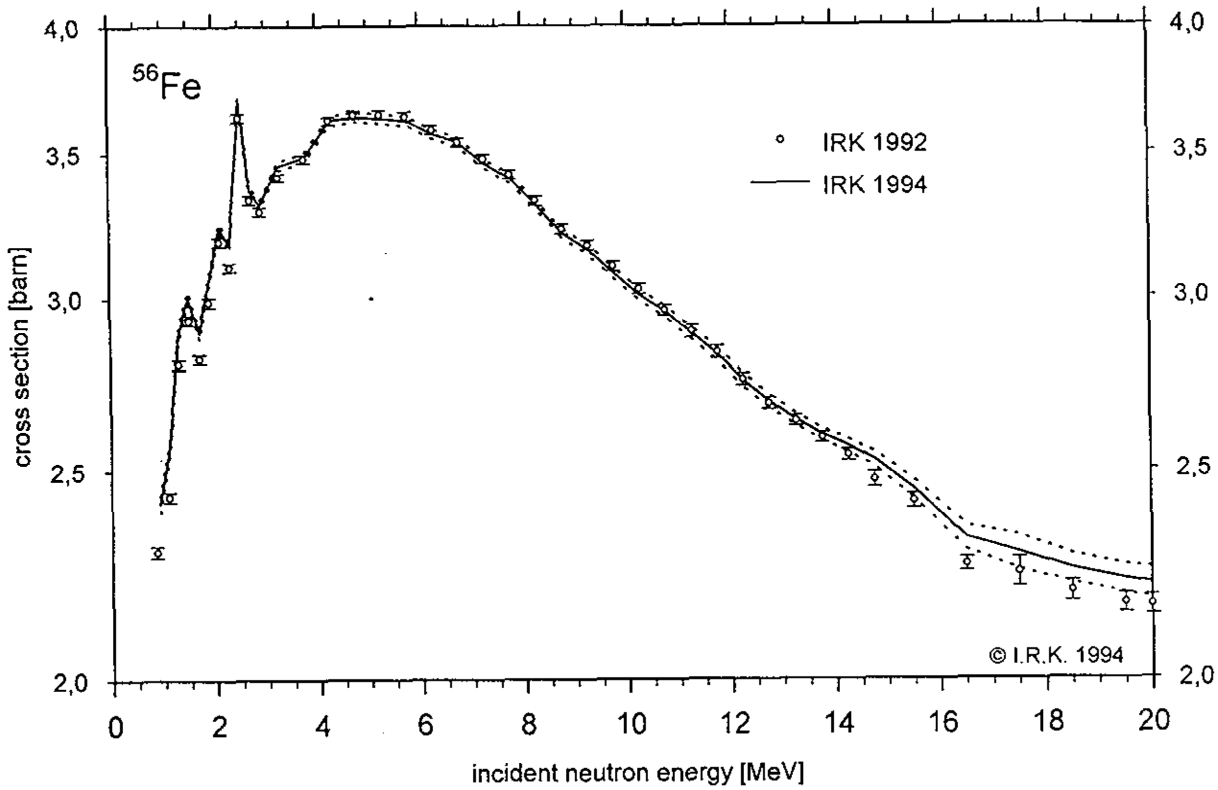


Figure 35

total cross section: Comparison of evaluations IRK-1992 and IRK-1994



21070079

Figure 36

elastic cross section: I.R.K. evaluation 1992 & new data

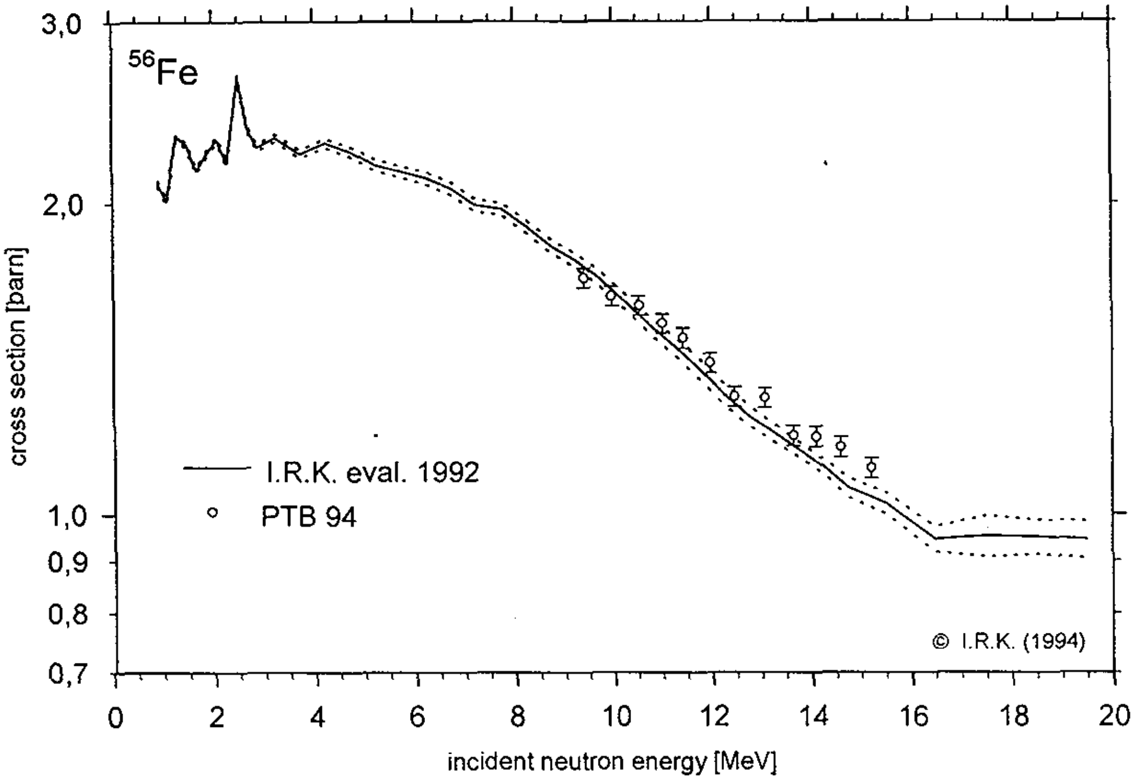
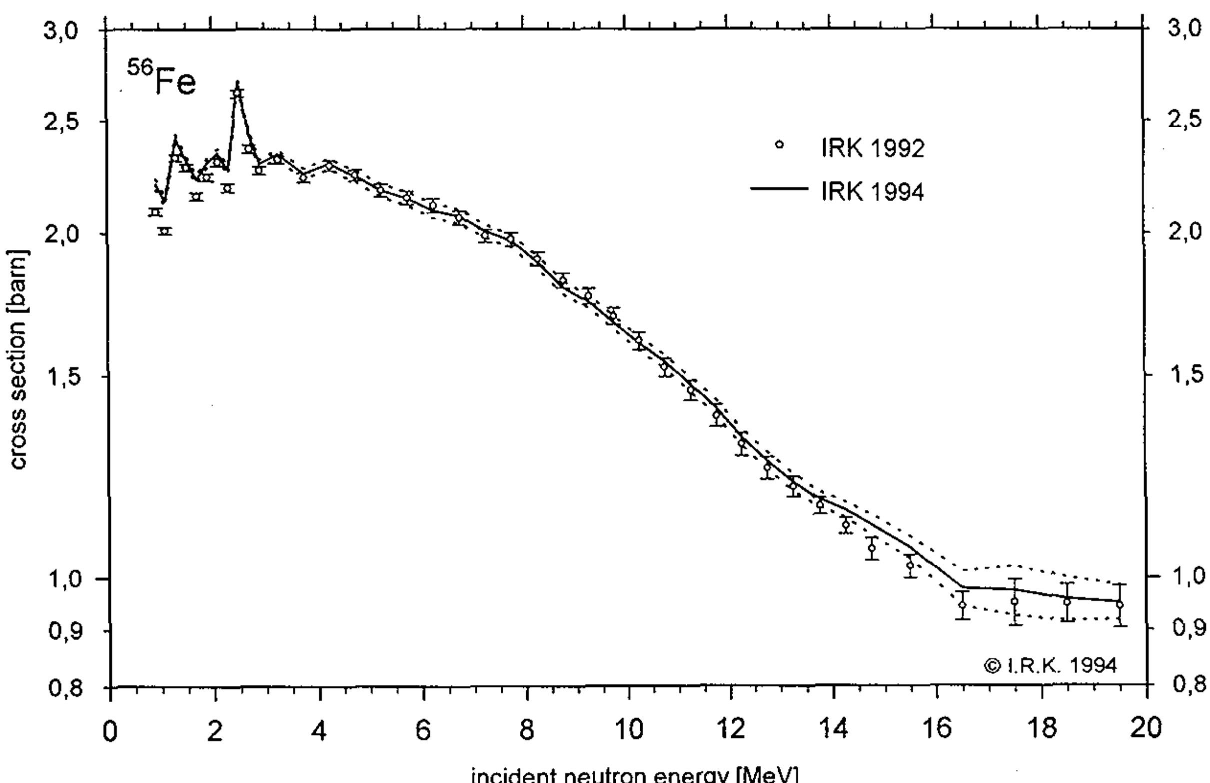


Figure 37

elastic cross section: Comparison of evaluations IRK-1992 and IRK-1994



2107007

Figure 38

(n,n$_1$) cross section: I.R.K. evaluation 1992 & new data

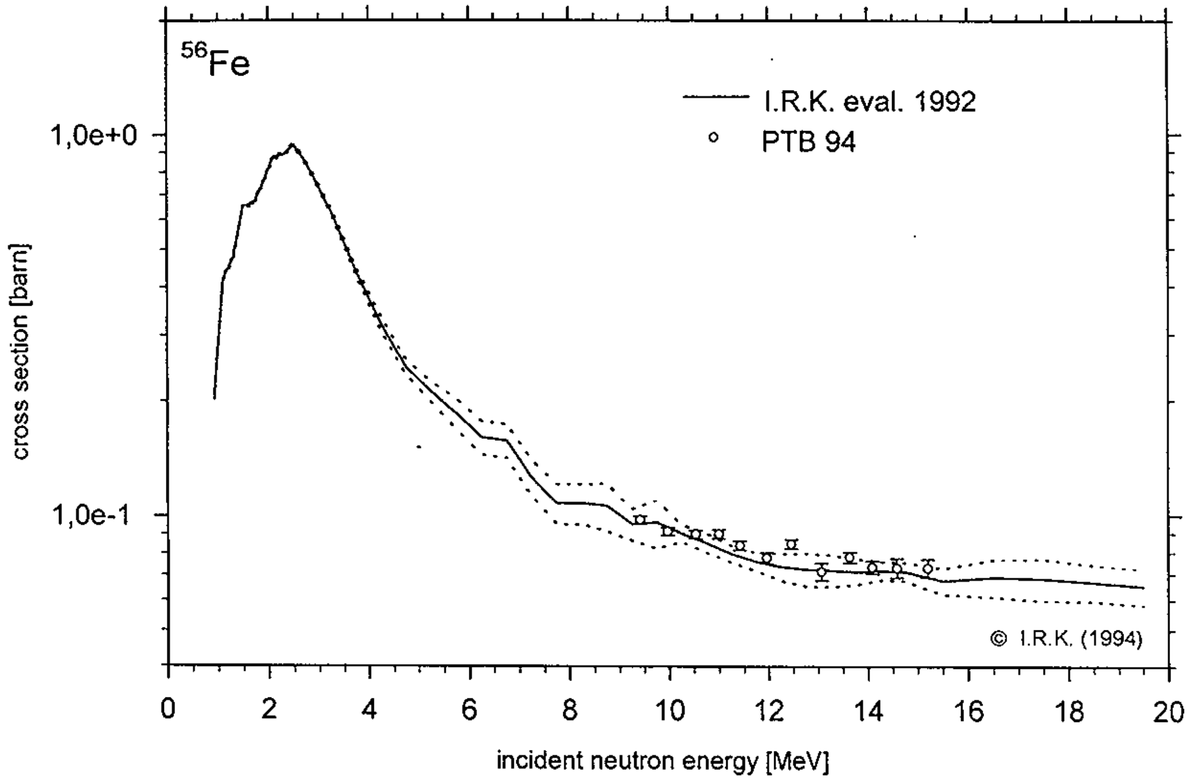
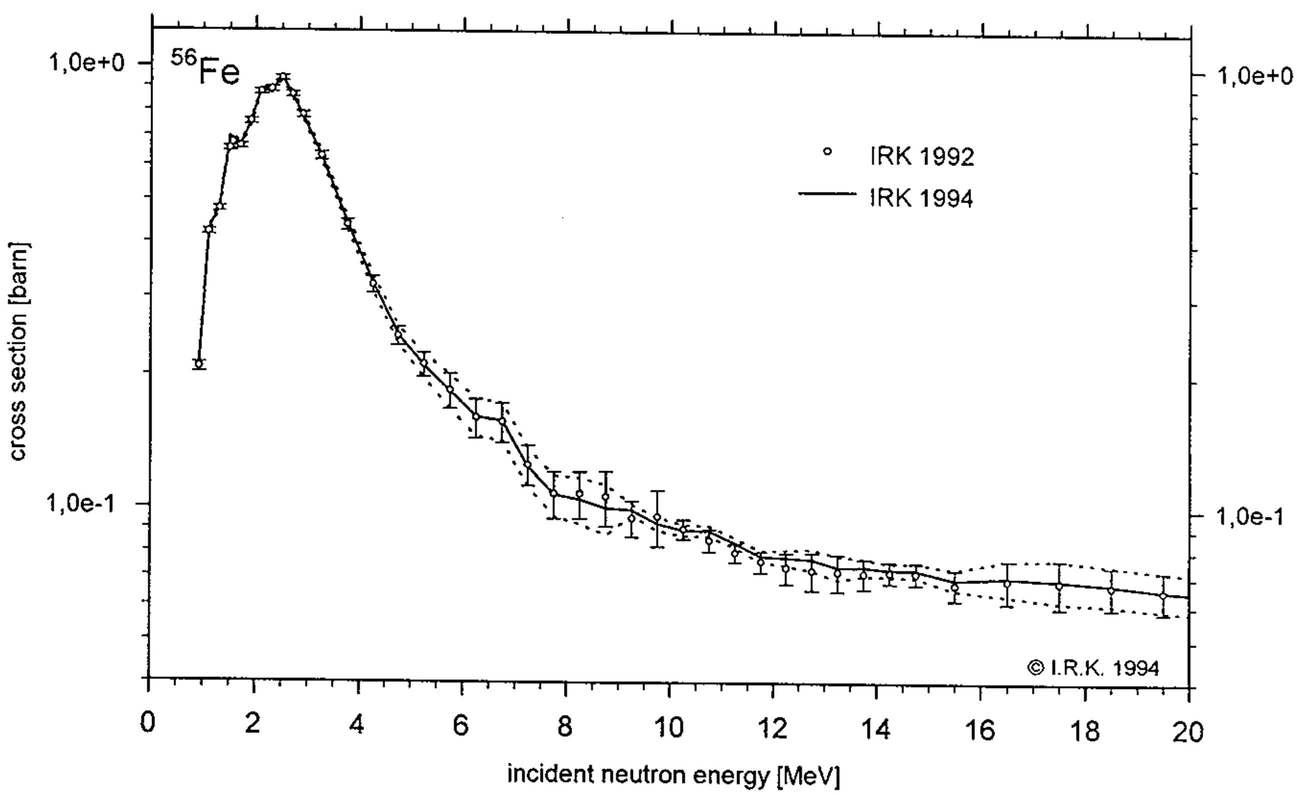


Figure 39

(n,n$_1$) cross section: Comparison of evaluations IRK-1992 and IRK-1994



21070074

Figure 40

(n,n_2) cross section: I.R.K. evaluation 1992 & new data

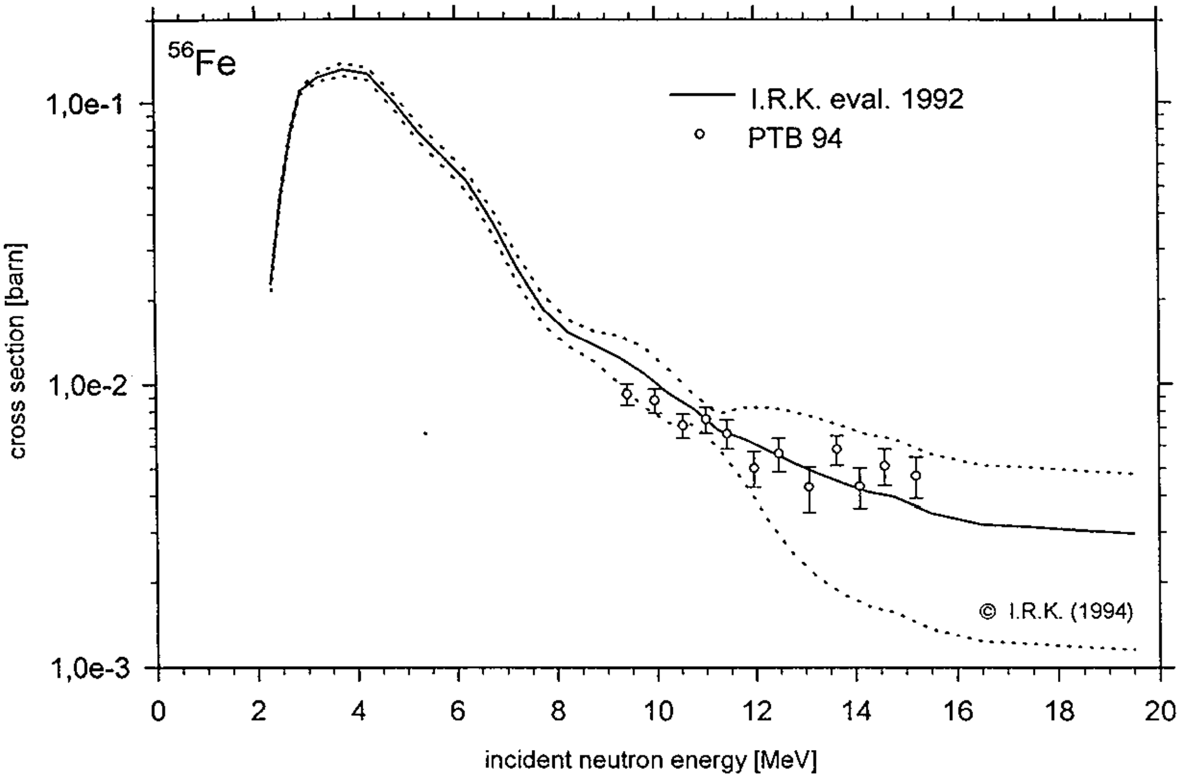
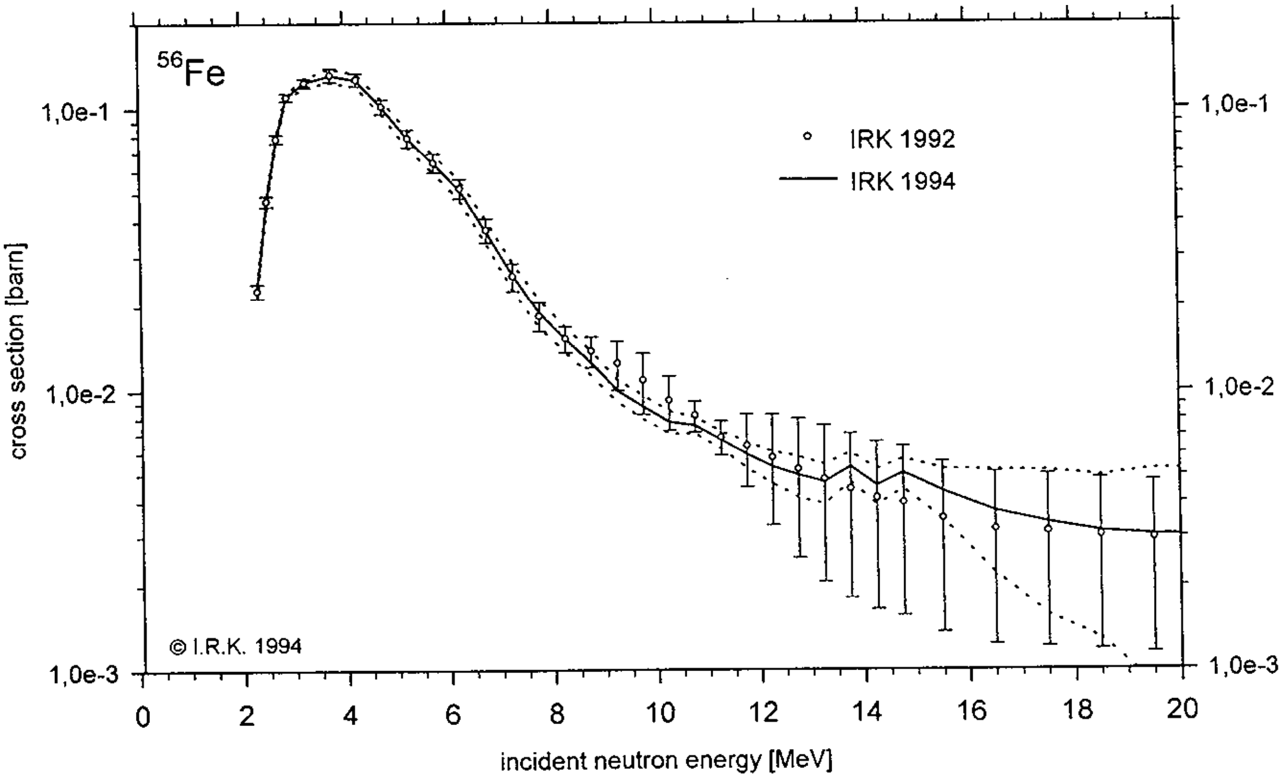


Figure 41

(n,n_2) cross section: Comparison of evaluations IRK-1992 and IRK-1994



21070075

Figure 42

(n,n_3) cross section: I.R.K. evaluation 1992 & new data

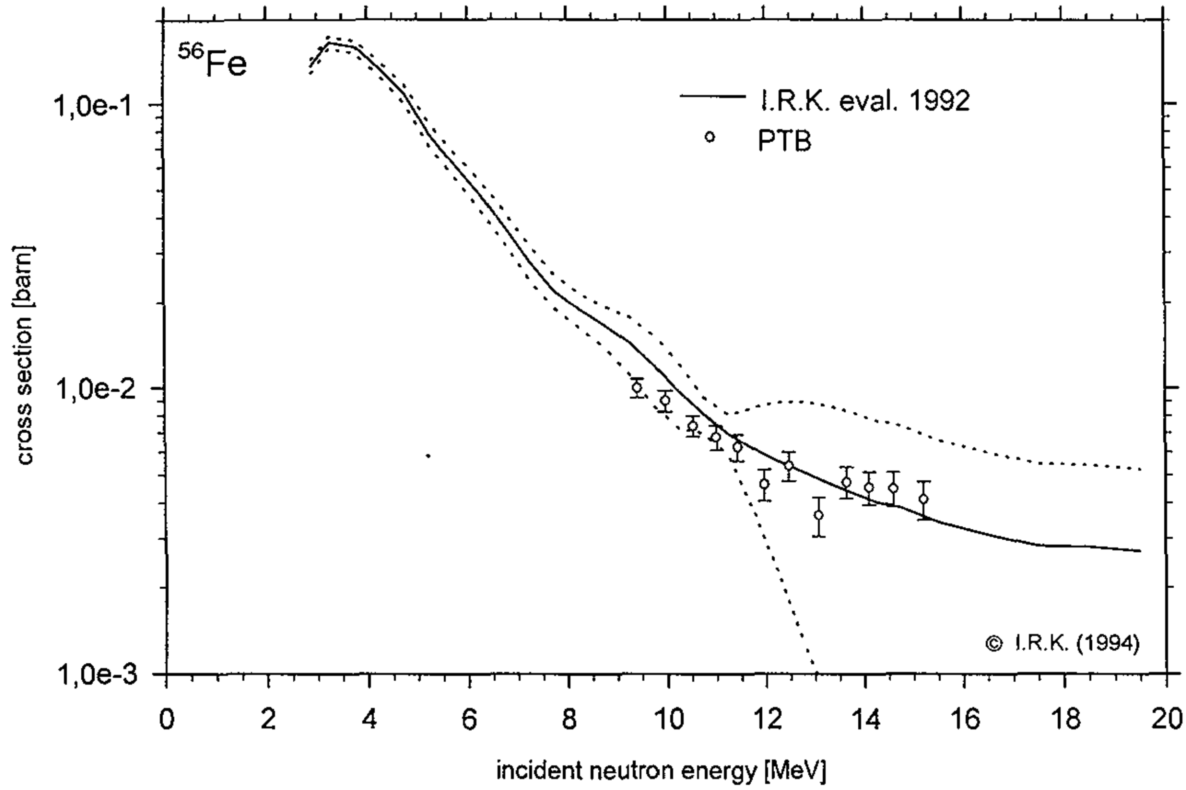


Figure 43

(n,n_3) cross section: Comparison of evaluations IRK-1992 and IRK-1994

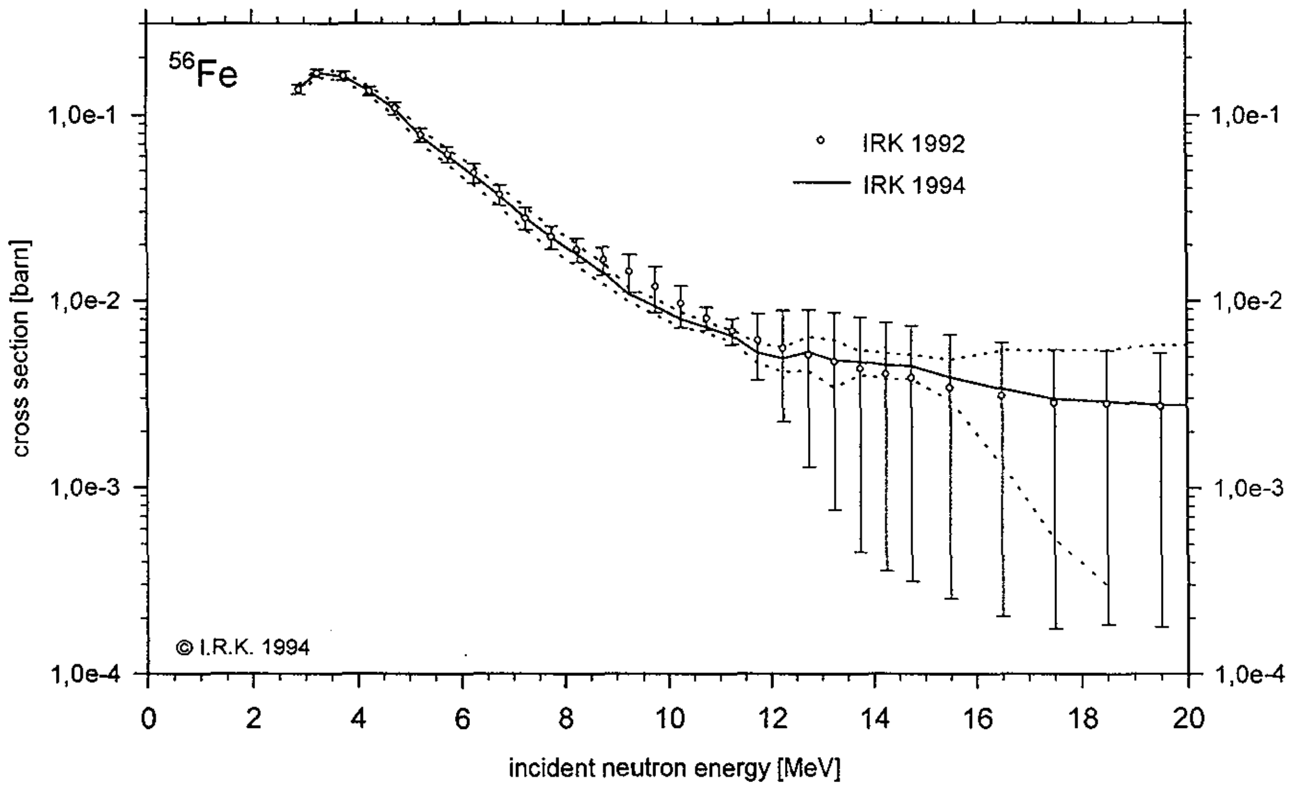


Figure 44

(n,n_{4-7}) cross section: I.R.K. evaluation 1992 & new data

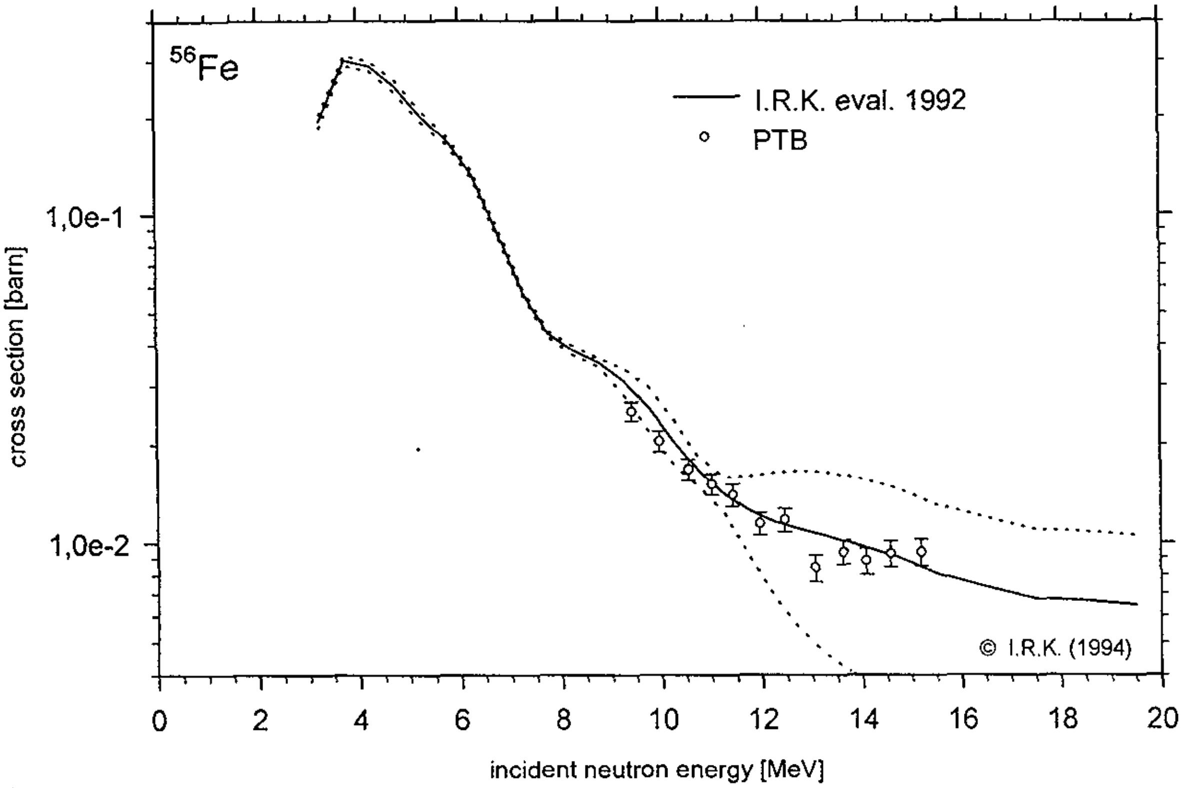
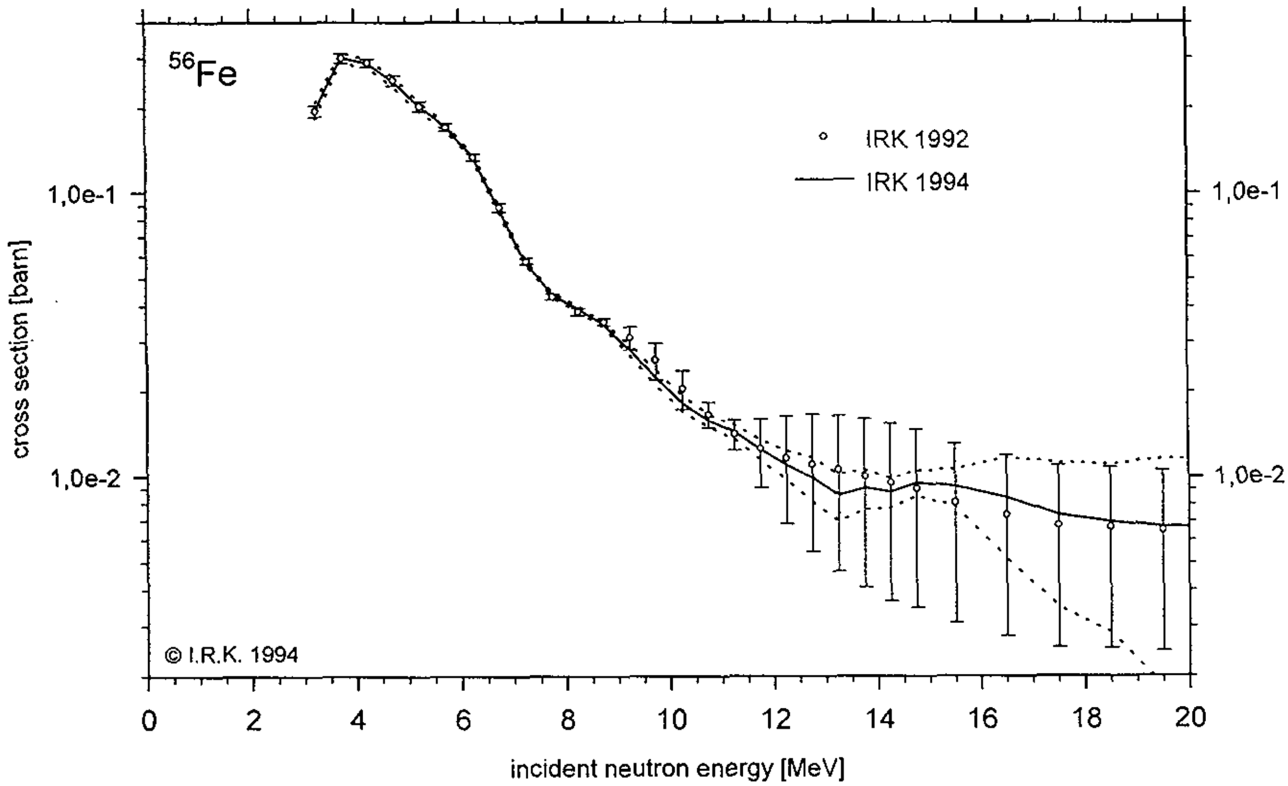


Figure 45

(n,n_{4-7}) cross section: Comparison of evaluations IRK-1992 and IRK-1994



21070077

Figure 46

(n,n$_{8-14}$) cross section: I.R.K. evaluation 1992 & new data

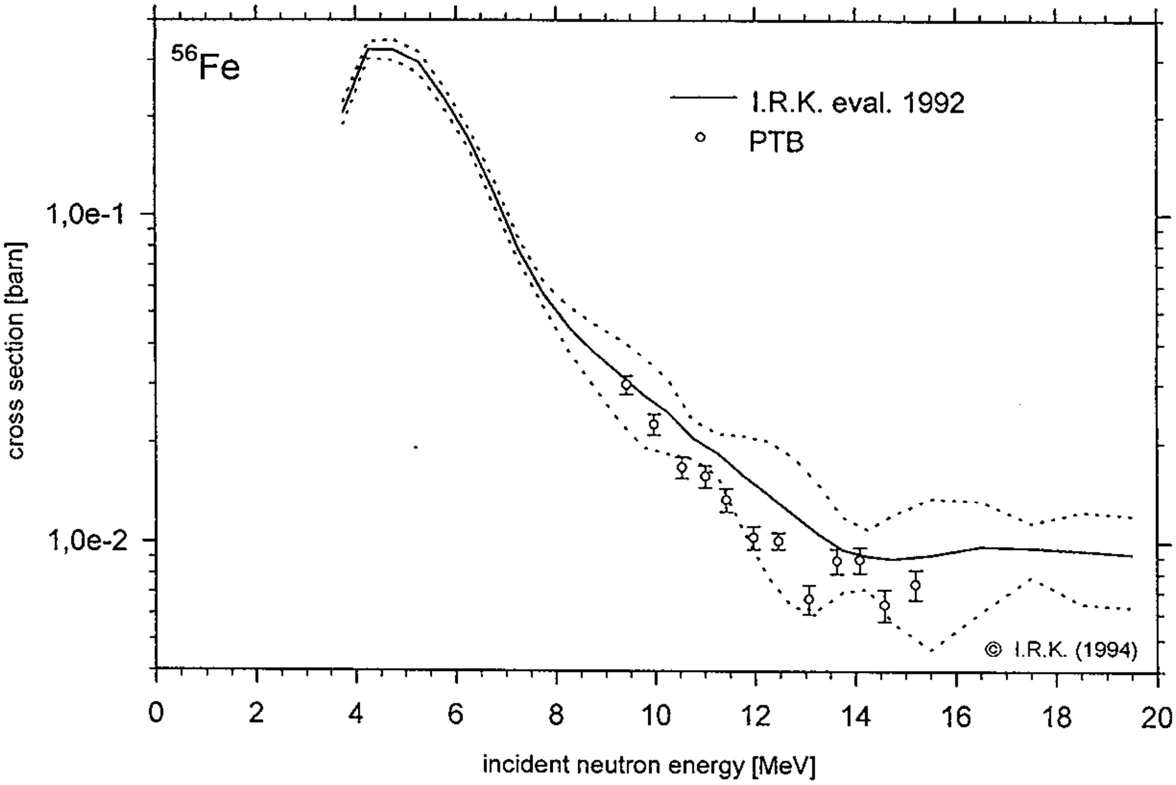


Figure 47

(n,n$_{8-14}$) cross section: Comparison of evaluations IRK-1992 and IRK-1994

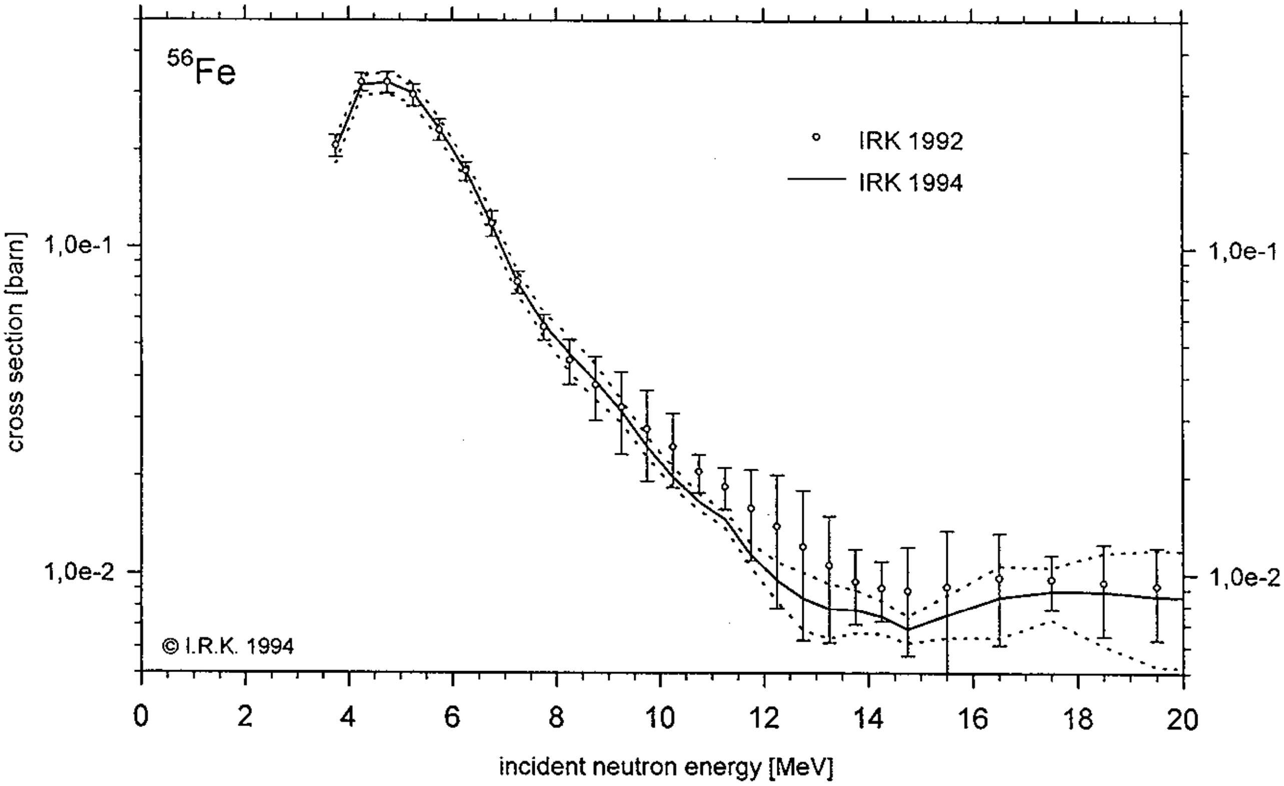


Figure 48

($n,n_{15\text{-}32}$) cross section: I.R.K. evaluation 1992 & new data

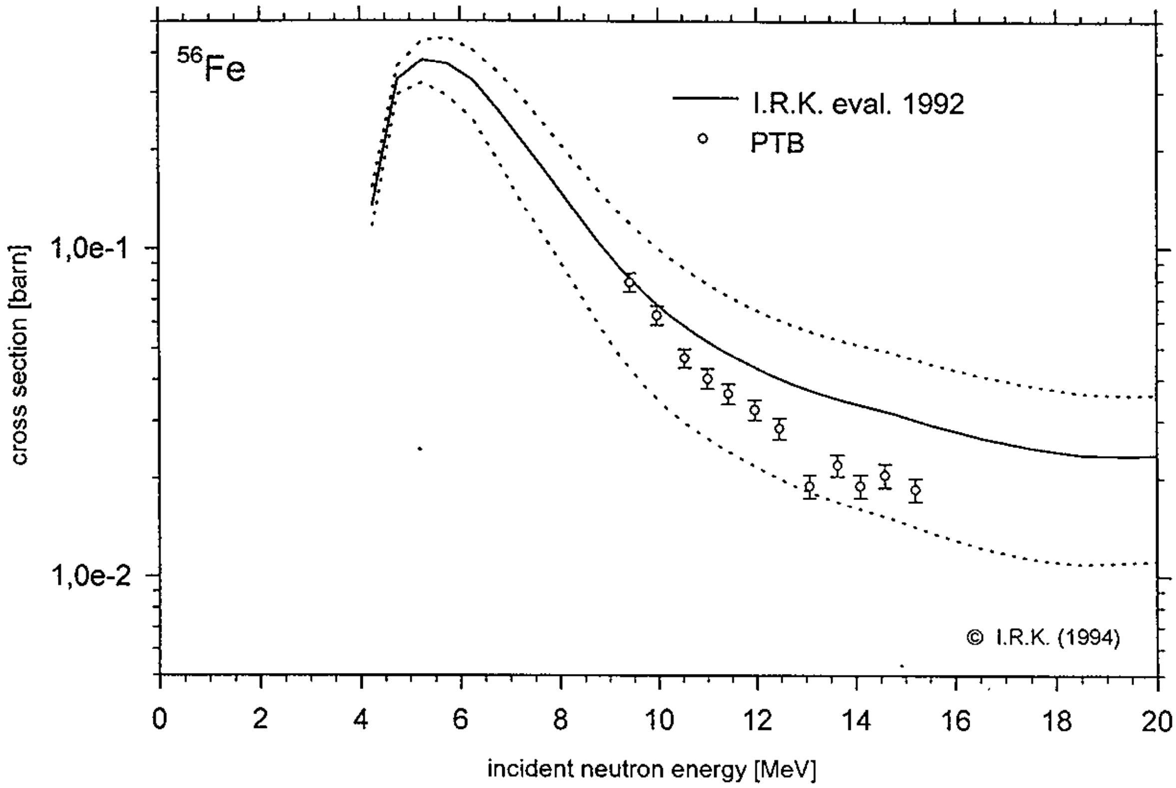
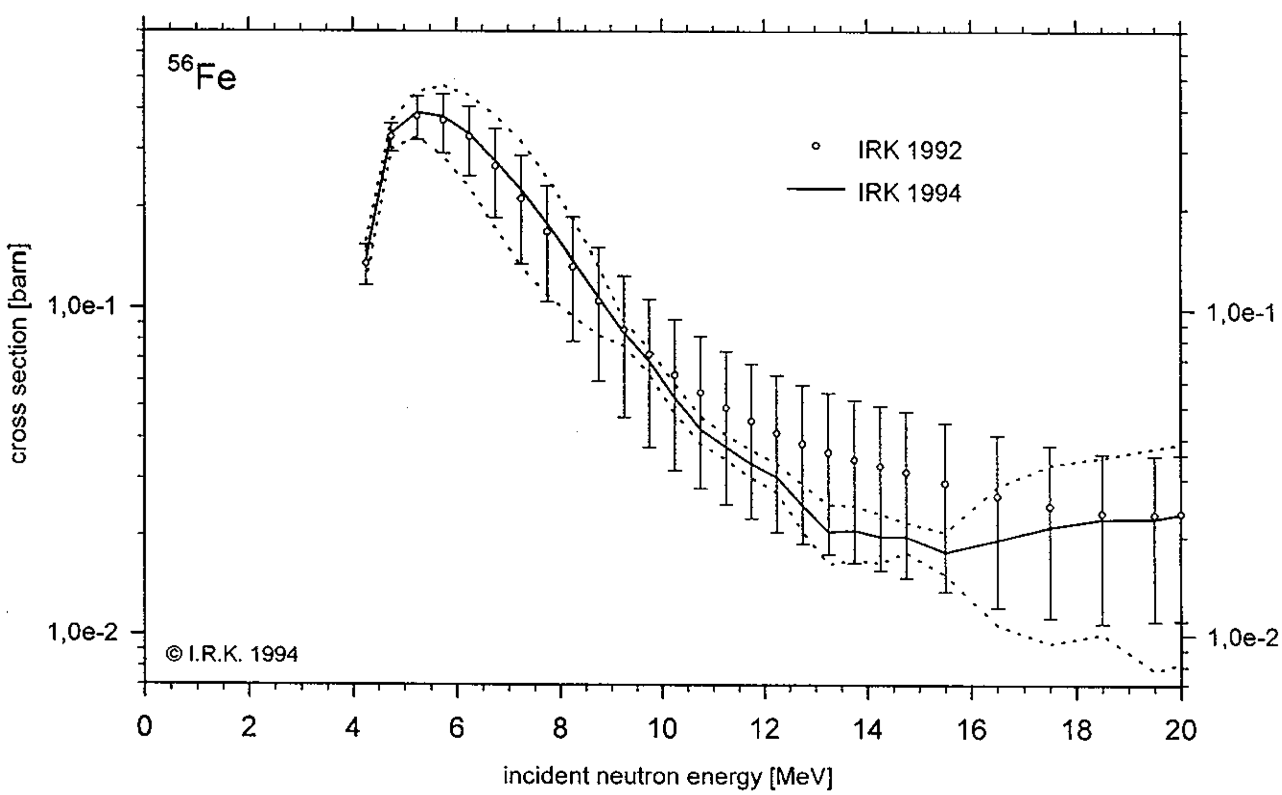


Figure 49

($n,n_{15\text{-}32}$) cross section: Comparison of evaluations IRK-1992 and IRK-1994



21070079

Figure 50

(n,α) cross section: I.R.K. evaluation 1992 & new data

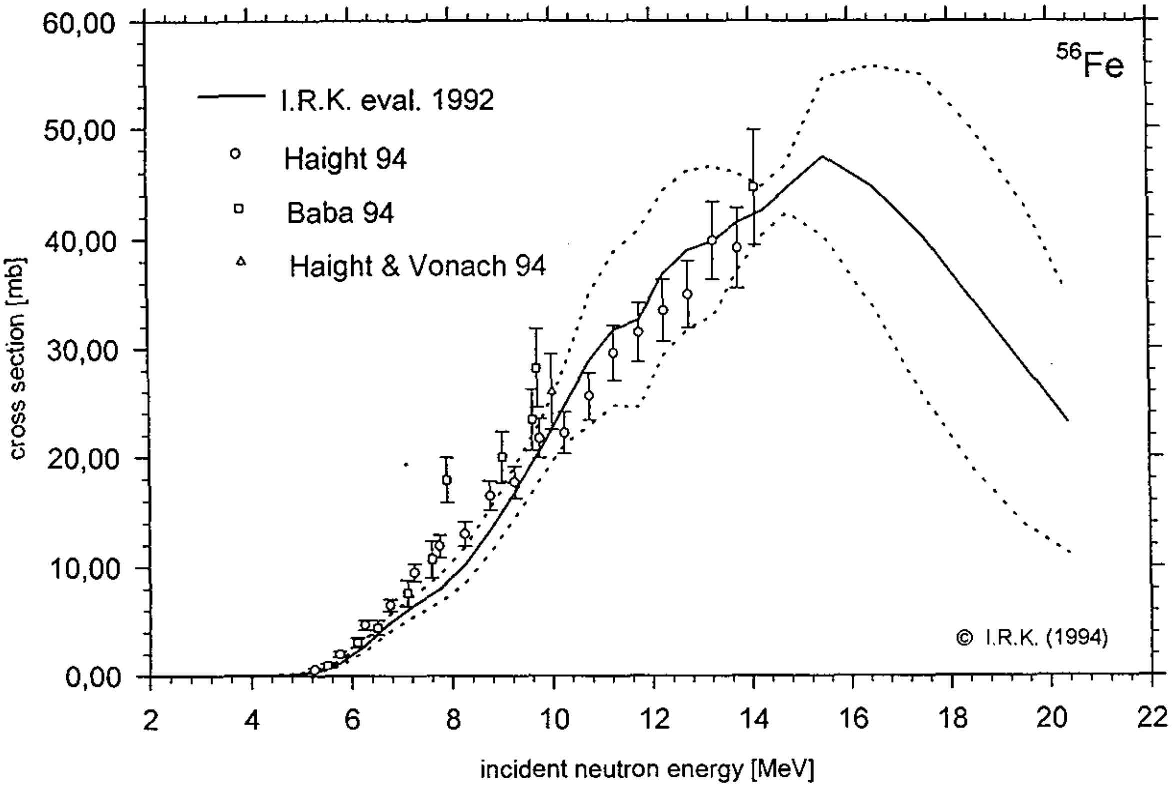


Figure 51

(n,α) cross section: Comparison of evaluations IRK-1992 and IRK-1994

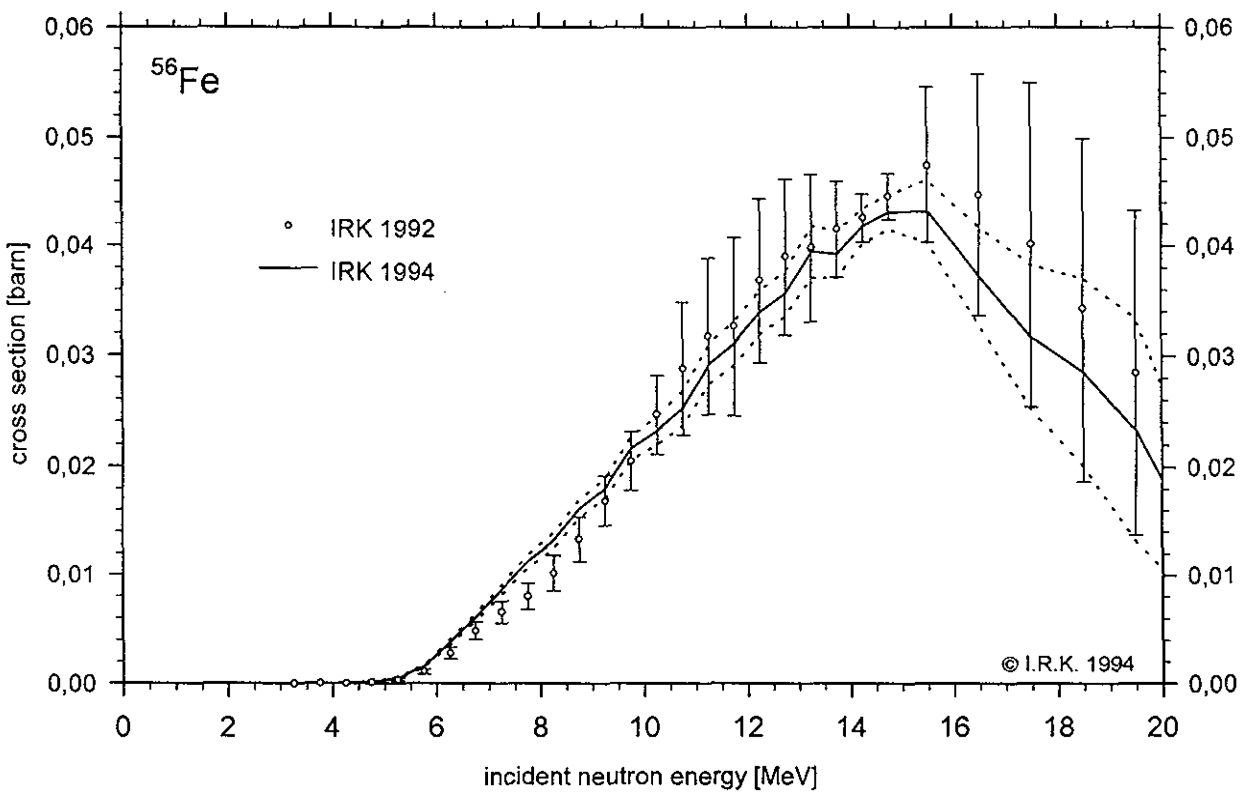


Figure 52

56Fe (total) correlation matrix

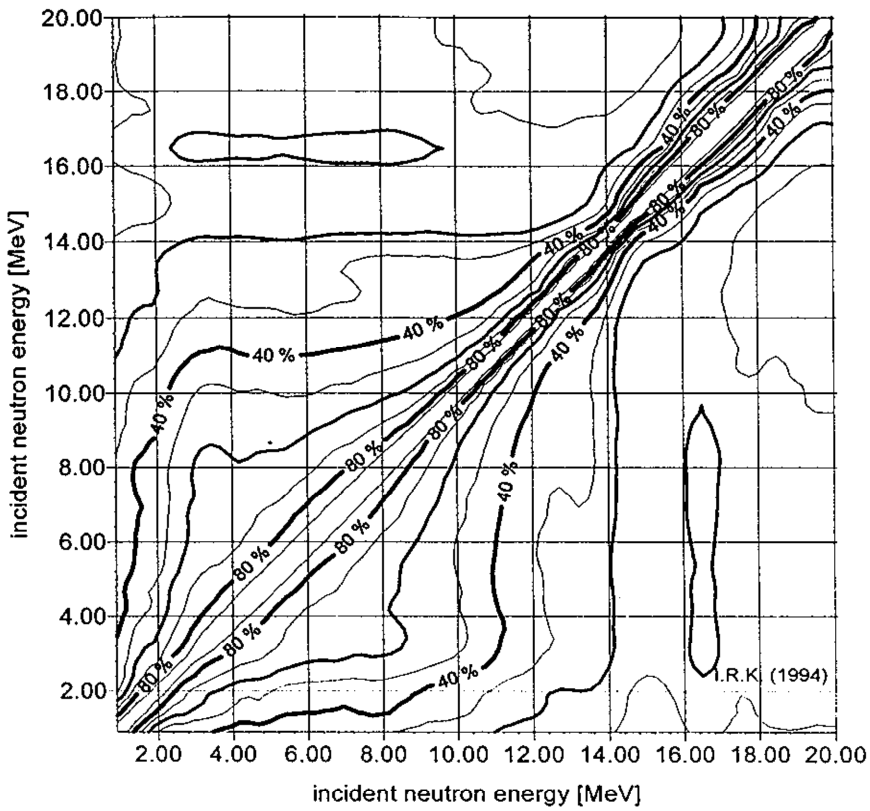
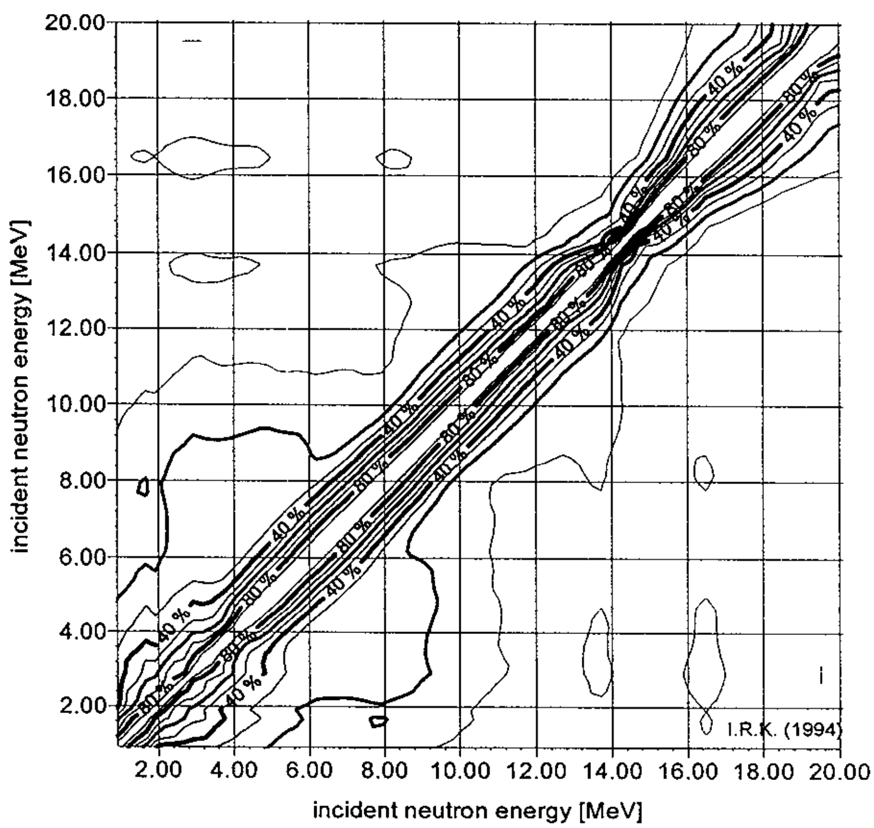


Figure 53

56Fe (elastic scattering) correlation matrix



21070081

Figure 54

56Fe (total inelastic) correlation matrix

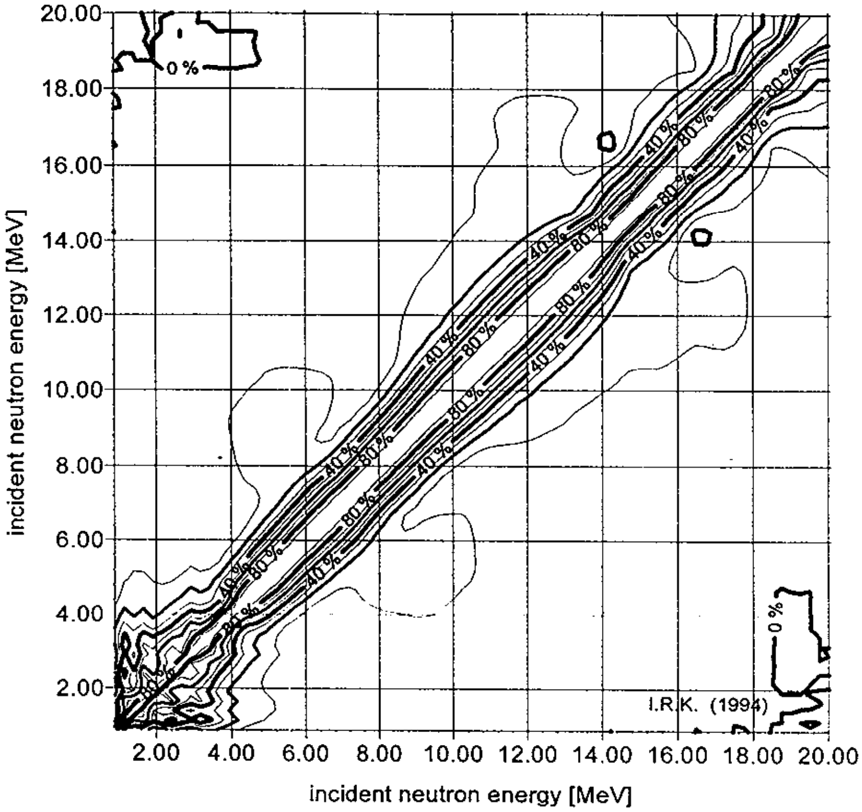
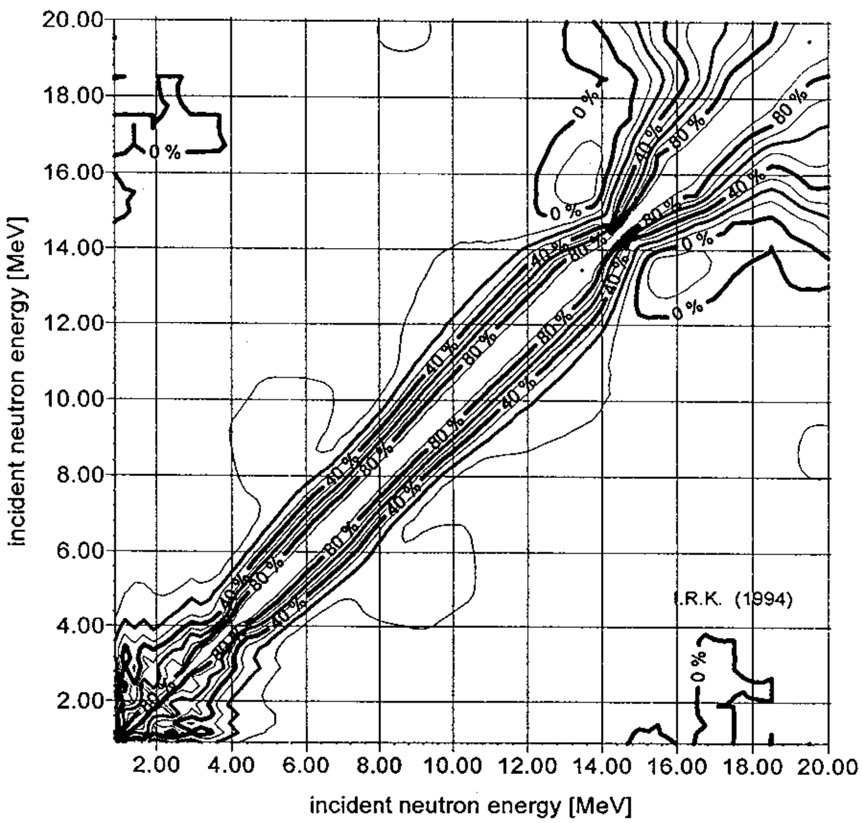


Figure 55

56Fe (nonelastic) correlation matrix



21070082

Figure 56

56Fe (n,2n) correlation matrix

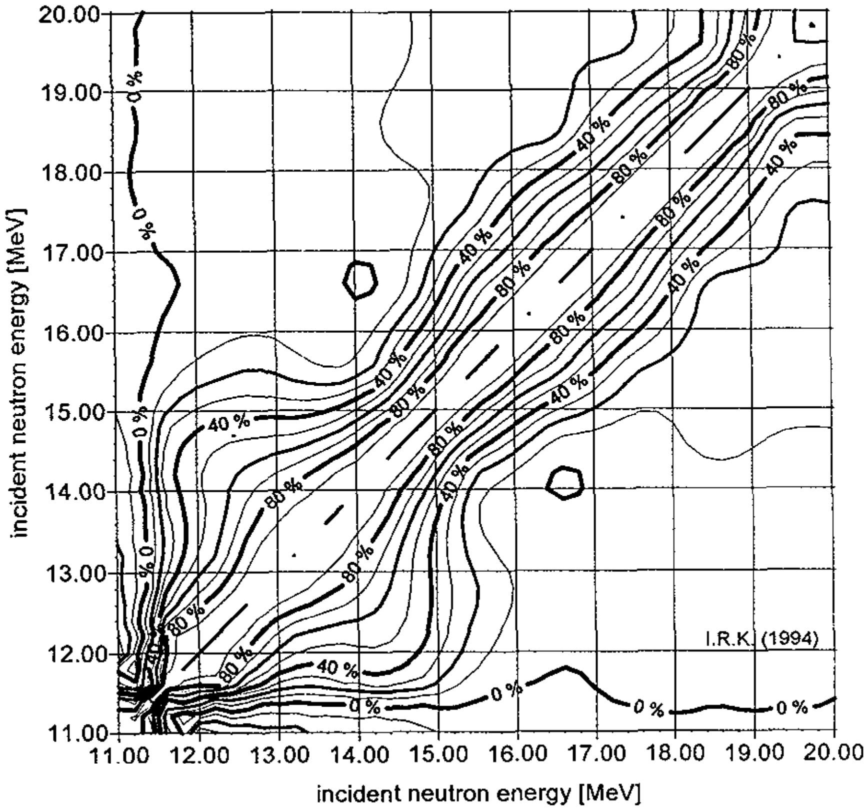
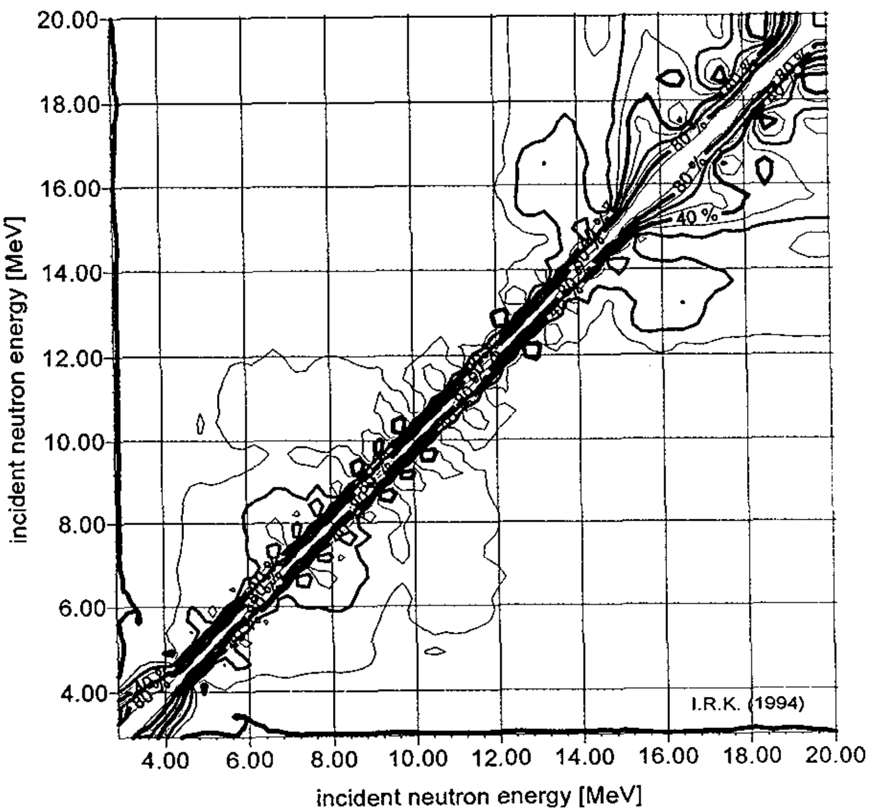


Figure 57

56Fe (n,p) correlation matrix



2107008?

Figure 58

total cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI

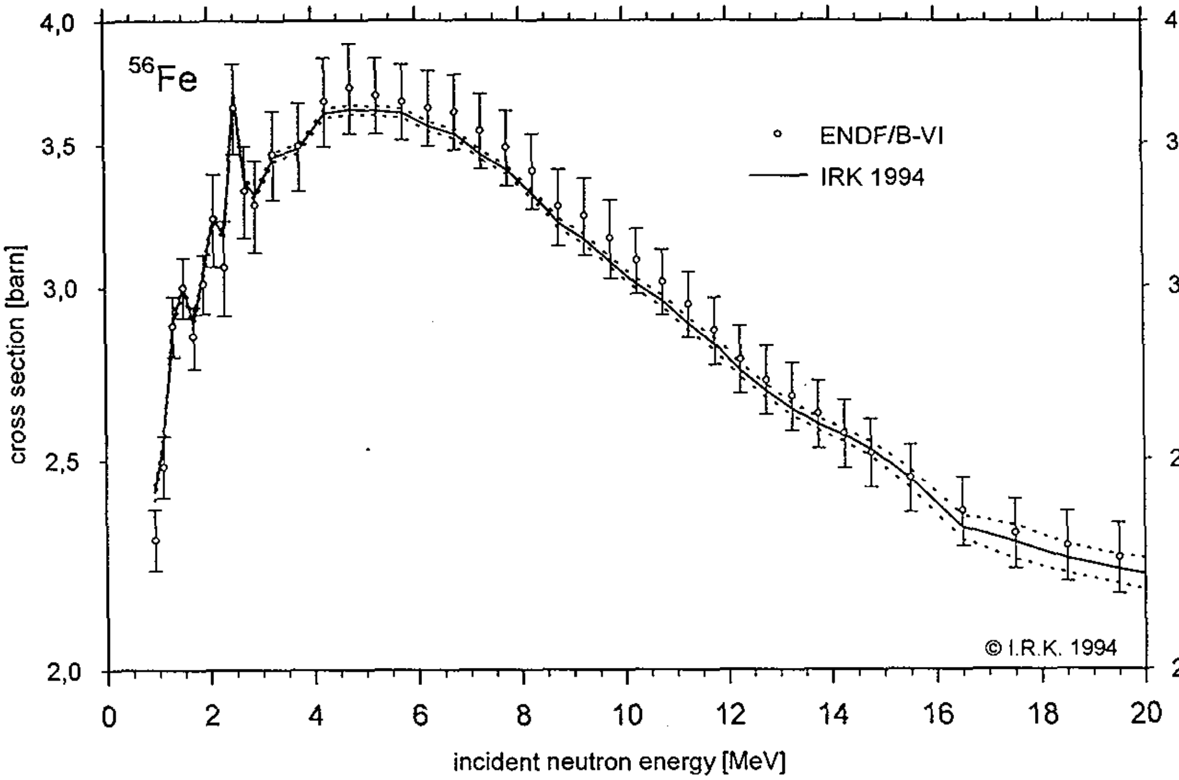
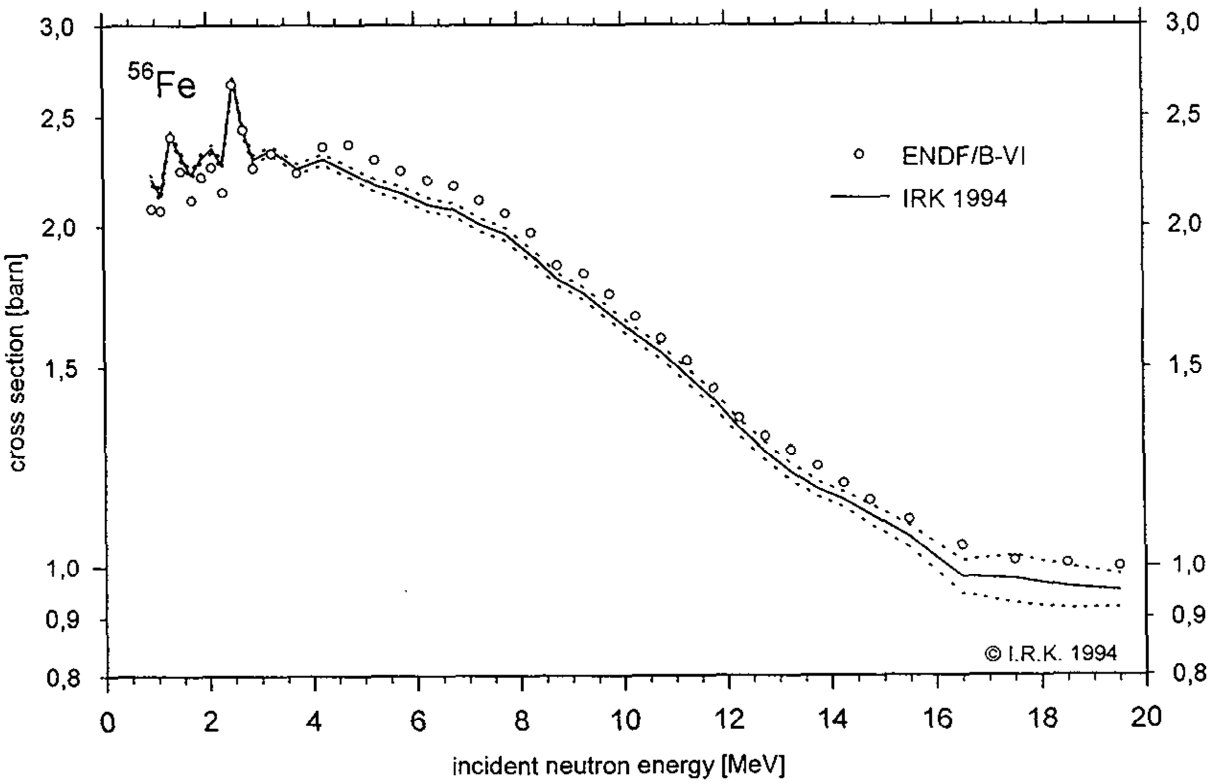


Figure 59

elastic cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI



2107008

Figure 60

nonelastic cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI

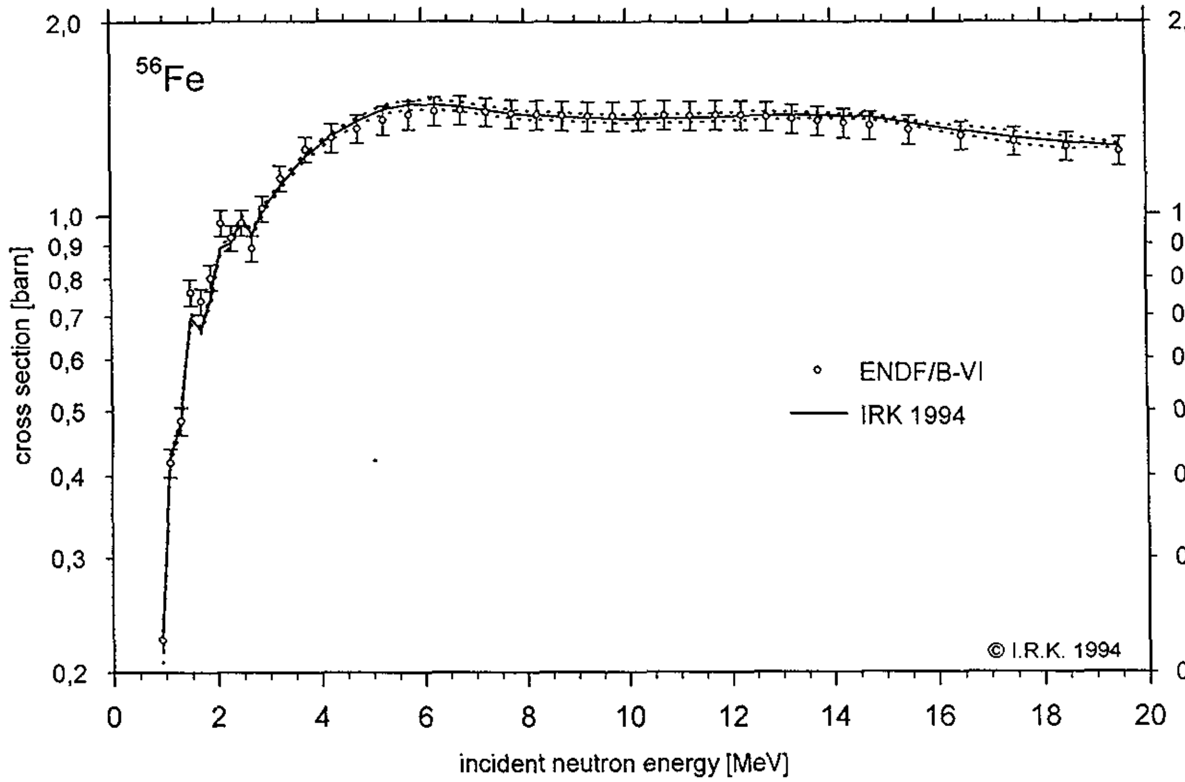
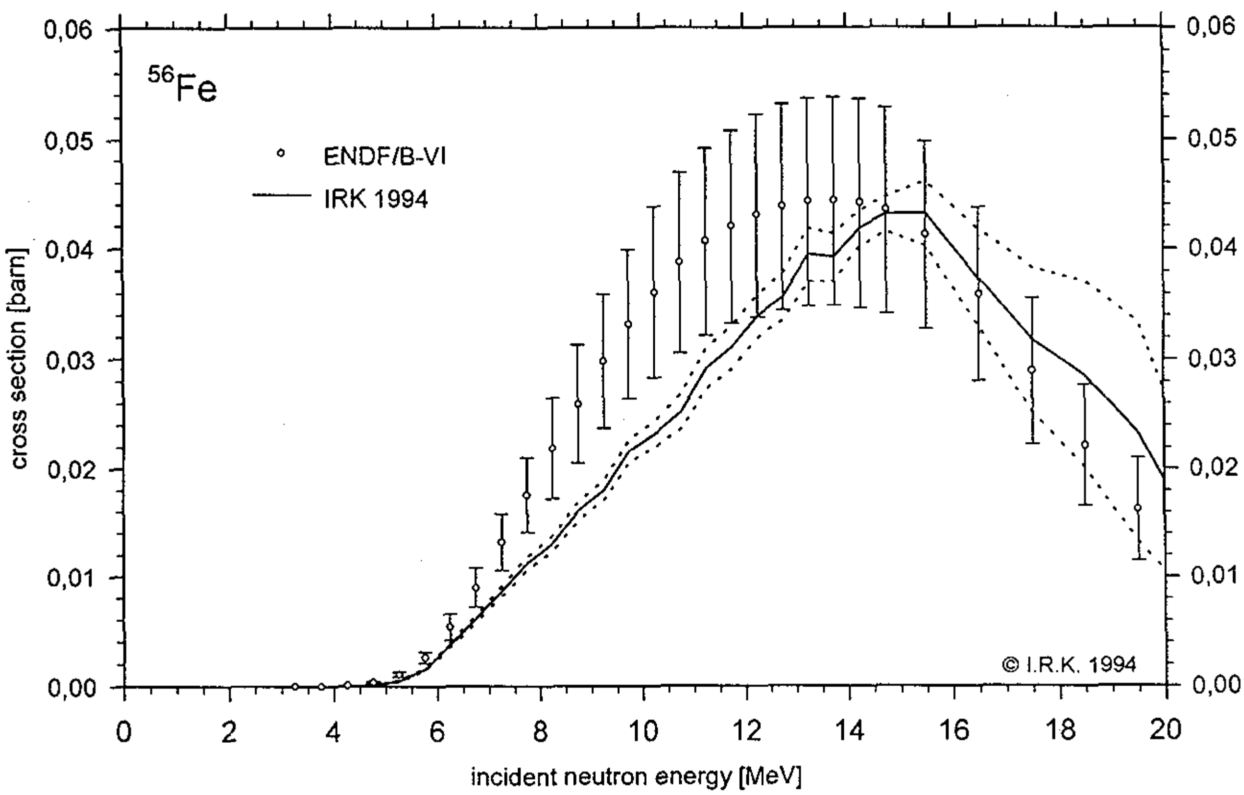


Figure 61

(n,α) cross section: Comparison of evaluations IRK-1994 and ENDF/B-VI



21070085

Note added in proof:

After completion of the manuscript it was detected that the effect of cross section fluctuations in the unresolved resonance range also result in systematic errors of all measurements of elastic, inelastic and nonelastic cross sections in the energy range below 4 MeV. For typical sample thickness used in scattering experiments this effect amounts to ≈ 5% at 1 MeV and decreases rapidly with increasing energy. For this reason all such data for ^{56}Fe were corrected for this effect using the relation

$$\sigma_{corr} = \sigma_{meas} / [1 - \frac{1}{2} \text{ nd } \sigma_{meas} (\frac{\Delta\sigma}{<\sigma>})^2]$$

whereby

n	= number of nuclei per cm^3 in scattering sample
d	= effective thickness of scattering sample
$\Delta\sigma/<\sigma>$	= relative variance of the total cross section.

This relation is based on equation 13 from the recent work of F. Fröhner [1]. The necessary values of the cross section variances $\Delta\sigma/<\sigma>$ were taken from figure 3 of ref. 1. The effective sample thicknesses were derived from the information given by the authors of the respective paper. In cases where this information was missing an average value for this thickness was used. Using the corrected values for σ_{el}, σ_{inel} and σ_{non} the whole evaluation for ^{56}Fe was repeated. This resulted in slightly higher values for σ_t, σ_{el}, σ_{inel} and σ_{non} in the energy range below 4 MeV and also in very satisfactory, much improved consistency between the values of σ_t, σ_{el} and σ_{non} in the unresolved resonance range. The tables describing the evaluation results are updated and give the results obtained with the corrected values of σ_{el}, σ_{non} and σ_{inel} in the energy range .85 – 4 MeV.

Reference:

Fröhner 94: F.H. Fröhner, Proc.Int.Conf. on Nuclear Data for Science and Technology, Gatlinburg, May 9–13, 1994, Ed. J.K. Dickens, Vol. 2, p. 597 (1995)