



# International Atomic Energy Agency

The 9th DAE-BRNS Workshop on

**Nuclear Reaction Data and its Compilation for EXFOR Database**

Department of Physics, Bharathiar University, Coimbatore India

14–18 November 2023

## EXFOR Format

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Nuclear Data Section

Department of Nuclear Sciences and Applications



## EXFOR Format

**1. Experimental Description**

2. Numerical Description



# Structure of BIB Section

	11		66	80
..				
AUTHOR	(	B.K.Nayak, A.Saxena, D.C.Biswas, E.T.Mirgule,	33023001	6
...				
INSTITUTE	(	3INDTRM)	33023001	9
REFERENCE	(	J,PR/C,78,061602,2008)	33023001	10
...				

- Coded information is designed for database search.
- Many abbreviations are defined in Dictionary.

## Example

3INDBDA: M.S. University of Baroda (Institute code)

PRM: Pramana (Journal code)

,SIG: Cross section (Quantity code)



# Experimental Condition of EXFOR 33080.002

```

SUBENT      33080002   20150107   3308000200001
BIB          9         15       3308000200002
REACTION    (34-SE-78(N,P)33-AS-78,,SIG) 3308000200003
SAMPLE      (34-SE-78,NAT=0.2377) 3308000200004
            Natural SeO2 (purity of 99.99%) powder ← 3308000200005
            (26-FE-56,NAT=0.9175) 3308000200006
            Natural Fe (purity of 99.99%) powder 3308000200007
DECAY-DATA  (33-AS-78,90.7MIN,DG,614.,0.54) ← 3308000200008
MONITOR     (26-FE-56(N,P)25-MN-56,,SIG) 3308000200009
DECAY-MON   (25-MN-56,2.578HR,DG,847.,0.99) 3308000200010
MONIT-REF   (41240001,A.A.Filatenkov+,R,RI-252,1999) 3308000200011
METHOD      (ACTIV) Irradiated for 5400 sec., then measured for 3308000200012
            900 sec. 3308000200013
            (MOMIX) SeO2 and Fe powder (total weight of ~1 g) 3308000200014
            packed in a polyethylene bag (10 mm x 10 mm) ← 3308000200015
ERR-ANALYS (MONIT-ERR,2.,3.7) 56Fe(n,p)56Mn cross section (2-3.7%) 3308000200016
STATUS      (TABLE) Table II of Phys.Rev.C90(2014)064609 3308000200017
ENDBIB      15         0       3308000200018
NOCOMMON    0         0       3308000200019
DATA        3         5       3308000200020
EN          DATA     DATA-ERR 3308000200021
MEV         MB        MB        3308000200022
 13.73      15.6      1.5     3308000200023
 14.07      17.       1.6     3308000200024
 14.42      18.6      1.6     3308000200025
 14.68      20.4      1.7     3308000200026
 14.77      22.       1.7     3308000200027
ENDDATA     7         0       3308000200028
ENDSUBENT   27        0       3308000299999
    
```

Natural SeO<sub>2</sub>  
(enrichment=23.7%)  
powder used.

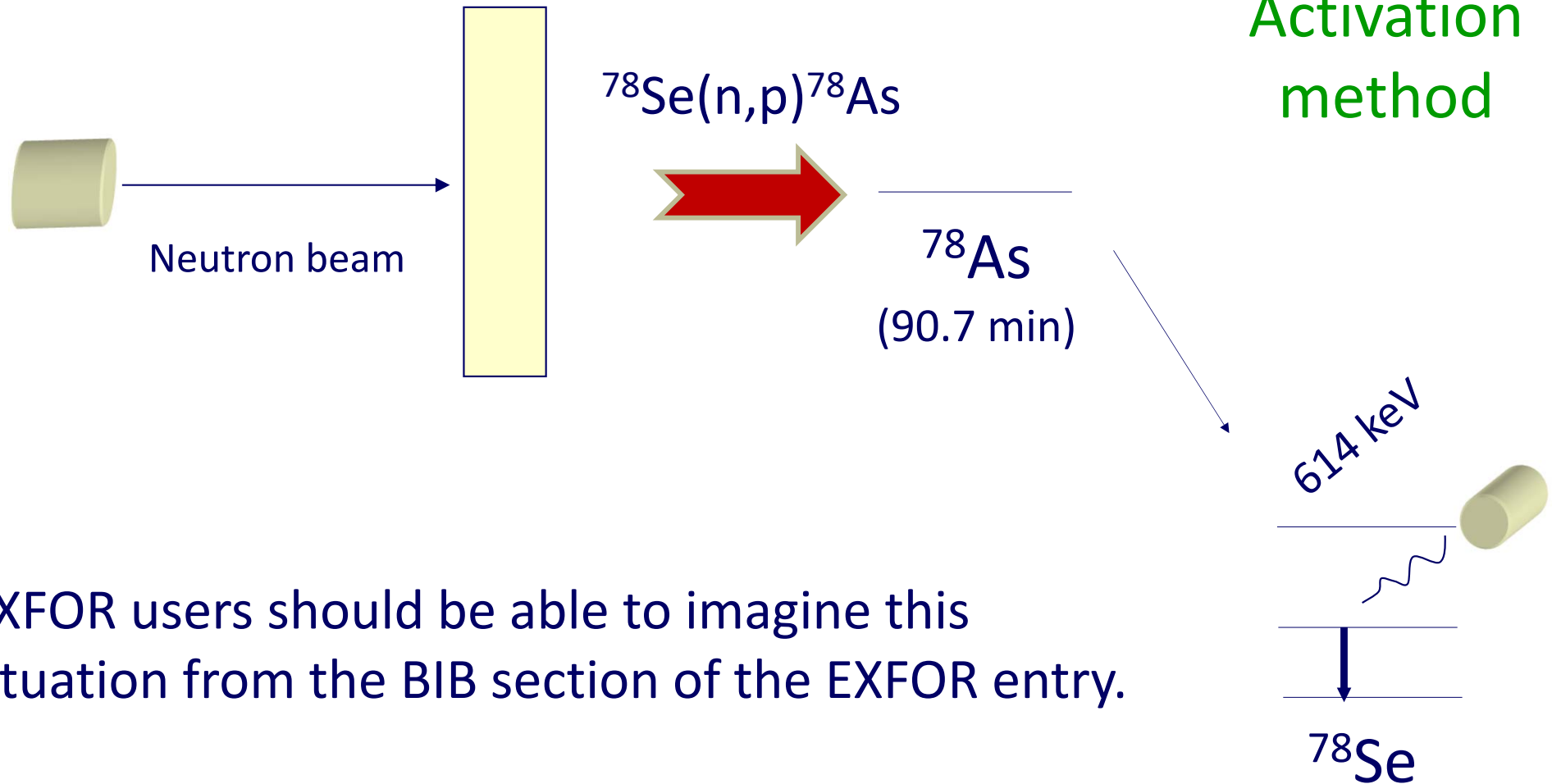
614 keV  $\gamma$ -ray  
(I <sub>$\gamma$</sub> =54%) used.

SeO<sub>2</sub> reaction sample  
powder mixed with Fe  
monitor powder used.



# Experimental Condition of EXFOR 33080.002

SeO<sub>2</sub> (<sup>78</sup>Se: 23.77%) powder  
mixed with Fe powder



EXFOR users should be able to imagine this situation from the BIB section of the EXFOR entry.

# Keyword, Code and Free text

- Keyword is given in 1<sup>st</sup> to 11<sup>th</sup> columns.
- Code(s) follow an open parenthesis at the 12<sup>th</sup> column.
- Free text is given between 12<sup>th</sup> to 66<sup>th</sup> column

## Example

	11	22	33	44	55	66	Free text only
TITLE	The 5th DAE-BRNS Theme Meeting on EXFOR Compilation of Nuclear Data						}
AUTHOR	(B.Rudraswamy, B.R.Behera, A.Kumar, A.Saxena)						
INSTITUTE	(3INDPUC) Department of Physics						}
	(3INDTRM) Nuclear Physics Division						

coded information only

coded information + free text



# Major Keywords (Bibliography)

Keyword	Contents
TITLE	Title of the experimental work
AUTHOR	Researchers contributes to the work
INSTITUTE	Institutes of authors
REFERENCE	Articles used for compilations

## Example

	11	22	33	44	55	66
	-----+	-----+	-----+	-----+	-----+	-----+
TITLE	Radiative capture cross-sections of isotopes of Gd, Sm and V between 1 and 3 MeV					
AUTHOR	(M.Afzal Ansari, R.K.Yasikul Singh, M.L.Sehgal, V.K.Mittal, D.K.Avasthi, I.M.Govil)					
INSTITUTE	(3INDMUA, 3INDPUC)		<i>Aligarh Muslim Univ.+Punjab Univ.</i>			
REFERENCE	(J, ANE, 11, 173, 1984)		<i>Ann.Nucl.Energy 11(1984)173</i>			



# Major Keywords (Experimental Description)

Keyword	Contents
FACILITY	Experimental facility (reactor, accelerator etc.)
INC-SOURCE	Source of beam (for neutron and photon beam)
INC-SPECT	Spectrum of beam (for neutron and photon beam)

## Example

11                      22                      33                      44                      55                      66  
-----+-----+-----+-----+-----+-----+  
FACILITY    (CYCLO, 3INDPUC)    *Cyclotron at Punjab University*  
INC-SOURCE (P-T)                       *$^3\text{H}(p,n)^3\text{He}$  neutron source*





# Major Keywords (Experimental Description)

Keyword	Contents
SAMPLE	Sample specification (enrichment etc.)
DETECTOR	Detector used in the experiment
METHOD	Experimental method
ANALYSIS	Experimental data derivation

## Example

	11	22	33	44	55	66
	-----+	-----+	-----+	-----+	-----+	-----+
SAMPLE	(64-GD-160, ENR=0.981)	48.42	mg/cm <sup>2</sup>	<sup>160</sup> Gd (enrichment 98.1%)		
DETECTOR	(GELI)			<i>Ge(Li) detector used</i>		
METHOD	(ACTIV)			<i>Activation technique used</i>		



# Major Keywords (Parameters)

Keyword	Contents
MONITOR	Standard reaction for normalization
DECAY-DATA	Decay property of reaction product
DECAY-MON	Decay property of standard reaction product
LEVEL-PROP	Level of reaction product (spin, parity)

## Example

	11	22	33	44	55	66
	-----+			-----+		
MONITOR	(53-I-127 (N,G)	53-I-128, ,	SIG)	<i><sup>127</sup>I(n,<math>\gamma</math>)<sup>128</sup>I used as reference reaction</i>		
DECAY-DATA	(64-GD-161, 3.7MIN, DG, 315., 0.229)	<i>315 keV decay gamma (I<sub><math>\gamma</math></sub>=22.9%) from <sup>161</sup>Gd measured</i>				
DECAY-MON	(53-I-128, 24.9MIN, DG, 443., 0.160)	<i>443 keV decay gamma (I<sub><math>\gamma</math></sub>=16.0%) from <sup>128</sup>I measured</i>				



# Major Keywords (Data Specification)

Keyword	Contents
REACTION	Reaction and quantity in the DATA section

## Example

11                      22                      33                      44                      55                      66  
-----+-----+-----+-----+-----+  
REACTION    (64-GD-160 (N,G) 64-GD-161, , SIG)  $^{160}\text{Gd}(n,\gamma)^{161}\text{Gd}$  cross section is given



# Major Keywords (Correction and Error)

Keyword	Contents
CORRECTION	Correction applied to the raw data
ERR-ANALYS	Specification of uncertainties (e.g. statistical)
COVARIANCE	Covariance or correlation information

## Example

11                      22                      33                      44                      55                      66  
-----+-----+-----+-----+-----+-----+-----+  
CORRECTION Corrected for self-absorption of neutrons in the sample  
ERR-ANALYS (ERR-T) Total uncertainty  
                  (ERR-S) Statistical uncertainty  
                  (ERR-1) Uncertainty in sample mass  
COVARIANCE Uncertainty in sample mass is fully correlated



# Major Keywords (Bookkeeping)

Keyword	Contents
STATUS	Status of data (source, approval, cross reference)
HISTORY	History of the EXFOR entry

## Example

```

          11          22          33          44          55          66
-----+-----+-----+-----+-----+-----+
STATUS    (TABLE) Table 2 of Ann. Nucl. Energy 11(1984)173
          (APRVD) Approved by S.Ganesan (2010-03-30)
HISTORY   (20100321C) Compiled by Paresh M. Prajapati
          (20110411A) Corrected by Megha Bhike
```



# EXFOR Formats Manual

All details of EXFOR Formats are described in the **EXFOR Formats Manual**. A pdf copy is available on NRDC web page (<http://www-nds.iaea.org/nrdc/>).



INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA-NDS-207  
Rev. 2015/08

**NUCLEAR DATA SERVICES**

DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

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## EXFOR Formats Manual

last revision edited by

Otto Schwerer  
IAEA Nuclear Data Section, Vienna, Austria

on behalf of the  
International Network of Nuclear Reaction Data Centres

August 2015

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International Atomic Energy Agency



# Example of EXFOR Formats Manual

**DECAY-DATA**. Gives the decay data for any nuclide occurring in the reaction measured as assumed or measured by the author for obtaining the data given<sup>1</sup>. See also **LEXFOR, Decay Data**.

1. If the keyword RAD-DET is used, an entry should also be made for DECAY-DATA. Also, if decay flags appear in the data section, they must be linked to an entry under DECAY-DATA, see below. Otherwise, its presence is optional, and free text or coded information, with or without free text, may be given.

If the keyword DECAY-DATA is present, the keyword HALF-LIFE may not be used. See also **LEXFOR, Half-Lives**.

2. The general format of the coding string consists of three major fields which may be preceded by a decay flag:

((flag)nuclide,half-life,radiation).

Embedded blanks are permitted in the code only at the beginning of a field or subfield. A code string may be broken for continuation onto the next record, but the break must come at the end of a field or subfield, *i.e.*, the comma separating the subfields should be the last character on the line.

Flag. The general format of the code is (*n*.), where *n* has a numerical value that also appears in the data section under the data heading DECAY-FLAG. The flag may be omitted, in which case its parentheses are also omitted. See also **LEXFOR, Flags**.

## Free Text – *Be short and precise!*

### Free Text

(See also EXFOR Formats Manual Chapter 3).

*Be short and precise!*

Lengthy free text information may hide essential free text information. The compiler should *avoid “copy and paste”* and should identify key information to be kept as free text.





# Free Text – *Be short and precise!* (cont)

## *How to make free text more effective?*

- Enter the free text under the keyword and code to which it pertains.

(3INDIND,2JPNJPN) Bangalore University and Sapporo University

→

(3INDIND) Bangalore University

(2JPNJPN) Sapporo University

- Do not expand coded information by free text in general.

(3INDBHU) ~~Baranas Hindu Univ.~~

- Use coded information instead of free text when possible.

Decay data were taken from R.B.Firestone et al., Table of Isotopes (1996)

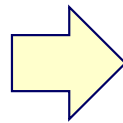
→

(N,,B,FIRESTONE,,1996) Decay data given

## Free Text – *Be short and precise!* (cont)

### (ACTIV, EXTB, STTA, GSPEC, MOSEP)

Excitation function was measured via the activation technique using stacked foil targets. Six stacks were irradiated at 16.0, 20.7 And 26.6 MeV. Irradiation time were between 0.5 and 2 hours, the beam current was 100 to 200 Na. The beam energy was measured directly by measuring the time between the beam bounches in Juelich, and was determined from the extraction radius and the cyclotron frequency in Debrecen. For monitoring the beam Ti and Cu foils were used.



(ACTIV) Irradiated for 0.5 to 2 hours with the beam current was 100 to 200 nA.

The beam energy was measured directly by measuring the time between the beam bounches in juelich, and was determined from the extraction radius and the cyclotron frequency in Debrecen.

(MOSEP) Ti and Cu foils used for monitoring the beam.

(STTA) Six stacks were irradiated at 16.0, 20.7 and 26.6 MeV.

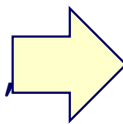
(EXTB, GSPEC)



## Free Text – *Be short and precise!* (cont)

**(2ITYBAU)** Istituto Nazionale di Fisica Nucleare (INFN), Bari, Italy. G.Tagliente, corresponding author, Email = giuseppe.tagliente@ba.infn.it; N.Colonna, S.Marrone, R.Terlizzi

**(2ITYTRI)** Istituto Nazionale di Fisica Nucleare (INFN), Trieste, Italy. K.Fujii, P.M.Milazzo, U.Abbondanno, F.Belloni, C.Moreau



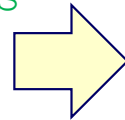
**(2ITYBAU, 2ITYTRI, 2FR SAC)**

**(2FR SAC)** CEA/Saclay-DSM/DAPNIA, Gif-sur-Yvette, France. G.Aerts, S.Andriamonje, E.Berthoumieux, W.Dridi, F.Gunsing, J.Pancin, L.Perrot, A.Plukis



## Free Text – *Be short and precise!* (cont)

Nuclear data were taken from E. Browne, R.B.Firestone, Table of radioactive isotopes, ed. V.S.Shirley, Wiley, 1986, New York. To calculate the particles energies in the foils Ziegler's stopping table was used. (J.F.Ziegler, the stopping and ranges of ions in matter, vol 3. Pergamon, New York, 1977)



(R, ,J.F.Ziegler, B,ANDERSEN, 3,1977)

Stopping power given

(R, ,E.Browne+, B,BROWNE, ,1986)

Decay data given



# Free Text – Don't copy and paste full sentence!!!

Common article ...

## II. EXPERIMENT

### A. Neutron irradiation

The neutron irradiation work was carried out at the 14 MeV neutron generator laboratory [7], Department of Physics, University of Pune, Pune, India. The 14 MeV neutrons were produced by bombarding deuterium ions of energy 175 keV on an 8 Curie tritium target. On the tritium target, the deuterium beam had a diameter ~4 mm and current ~100  $\mu$ A.

Copy and paste

INC-SOURCE (D-T) The 14 MeV neutrons were produced by bombarding 33080 1 37  
deuterium ions of energy 175 keV on an 8 Curie tritium 33080 1 38  
target. On the tritium target, the deuterium beam had 33080 1 39  
a diameter ~4 mm and current ~100 microA. 33080 1 40

INC-SOURCE (D-T) Deuterium ion beam (175 keV, ~4 mm in diam., 33080 1 11  
~100 uA on target) on an 8 Curie tritium target 33080 1 12

Extract essential information for free text (like TELEX).

This job is not for secretaries but for physicists!



# REACTION Code

REACTION code is the most important coded information in EXFOR. It defines quantity (DATA) given in the subentry.

...

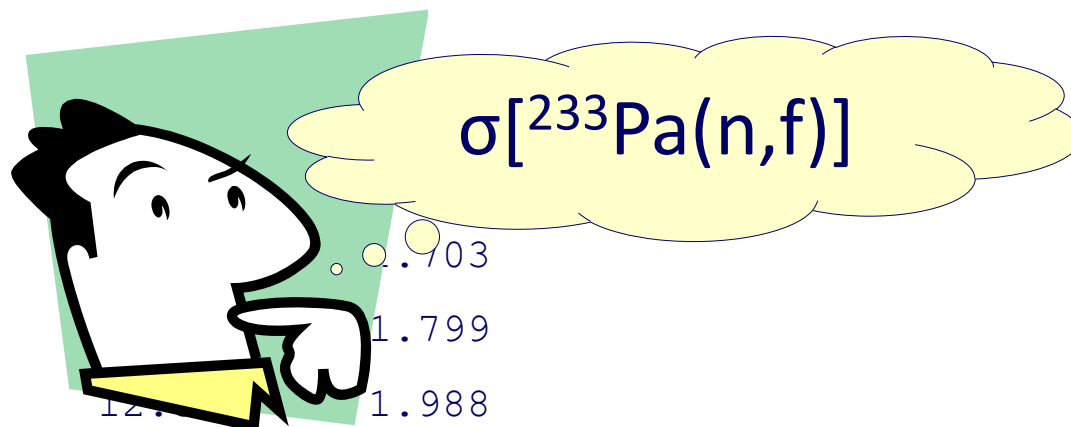
REACTION (91-PA-233 (N,F) , , SIG)

...

EN DATA ERR-S

MEV B B

11.83	0.8832	0.076	12.83	1.903
12.83	0.8754	0.076	13.84	1.799
13.84	0.8986	0.066	14.84	1.988
14.84	0.9444	0.071	15.85	2.091
15.85	1.1347	0.077	16.85	2.151
16.85	1.4780	0.1		2.122



# Sub Fields (SF) in REACTION Code

( SF1( SF2, SF3) SF4, SF5, SF6, SF7, SF8, SF9)

Reaction field

Quantity field

## Example

(30-ZN-67(N,P)29-CU-67,,SIG)

= Cross section of  $^{67}\text{Zn}(n,p)^{67}\text{Cu}$

(SF7,SF8 and SF9 are omitted)



## Sub Fields (SF) in REACTION Code (Cont)

### More Example

(30-ZN-67(N,P)29-CU-67,,DA)

= (Proton) angular distribution in  $^{67}\text{Zn}(n,p)^{67}\text{Cu}$  [mb/sr]

(30-ZN-67(N,N+P)29-CU-66,,DA,P)

= Proton angular distribution in  $^{67}\text{Zn}(n,np+pn)^{66}\text{Cu}$  [mb/sr]

(30-ZN-67(N,P)29-CU-67,PAR,DA)

= (Proton) partial angular distribution in  $^{67}\text{Zn}(n,p)^{67}\text{Cu}$  [mb/sr]

“partial” = data for a specific secondary (level, kinetic) energy





## Sub Fields (SF) in REACTION Code (Cont)

### More Example

(30-ZN-67(N,X)29-CU-66,,SIG)

=  $^{66}\text{Cu}$  production cross section from  $^{67}\text{Zn}(n,x)^{66}\text{Cu}$  [mb]

(Outgoing particle unknown - n+p? d?)

(30-ZN-67(N,X)1-H-1,,DA/DE)

= Proton double diff. cross section in  $^{67}\text{Zn}(n,p+x)$  [mb/sr/MeV]

(30-ZN-67(P,EL)30-ZN-67,,DA,,RTH)

= (Proton) Rutherford ratio in  $^{67}\text{Zn}(p,p_0)^{67}\text{Zn}$  [no dimension]



## Sub Fields (SF) in REACTION Code (Cont)

### More Example

(92-U-233(N,F)53-I-131,IND,FY)

= <sup>131</sup>I independent fission yield from <sup>233</sup>U(n,f) [nuclides/fission]

(“independent” = contribution of decay to <sup>131</sup>I excluded)

(98-CF-252(0,F),PR,NU)

= Prompt fission neutron multiplicity in <sup>252</sup>Cf spontaneous fission [neutrons/fission]

(92-U-235(N,F),PR,NU/DE)

= Prompt fission neutron spectrum in <sup>235</sup>U(n,f)

[neutrons/fission/MeV]



## Sub Fields (SF) in REACTION Code (Cont)

### More Example

(95-AM-241(N,G)95-AM-242-M,,SIG)

= Cross section for  $^{241}\text{Am}(n,\gamma)^{242\text{m}}\text{Am}$  [mb]

(91-PA-233(N,F),,SIG)/(92-U-235(N,F),,SIG)

= Cross section ratio for  $^{233}\text{Pa}(n,f)/^{235}\text{U}(n,f)$  [no dimension]

(91-PA-233(N,G)91-PA-234,,SIG,,MXW)

= Cross section for  $^{233}\text{Pa}(n,\gamma)^{234}\text{Pa}$  averaged for Maxwellian spectrum [mb]



# LEXFOR

- Major quantities defined in the EXFOR Formats are explained in **LEXFOR** (EXFOR Compiler's Manual) with corresponding REACTION code.

- A pdf copy is available on NRDC web page:  
<http://nds.iaea.org/nrdc/>



INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA-NDS-208  
Rev. 2015/08

**NUCLEAR DATA SERVICES**

DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

**LEXFOR**  
**(EXFOR Compiler's Manual)**

last revision edited by

Otto Schwerer  
IAEA Nuclear Data Section, Vienna, Austria

on behalf of the  
International Network of Nuclear Reaction Data Centres

August 2015

IAEA Nuclear Data Section, Vienna International Centre, A-1400 Vienna, Austria



# Example of LEXFOR

## Thermonuclear Reaction Rate

### Definition

The thermonuclear reaction rate is defined as cross section times ion velocity averaged over the Maxwellian-Boltzmann distribution of relative ion velocity distribution of the temperature  $kT$ .

$$\langle \sigma \cdot v \rangle = \frac{\int_0^{\infty} (\sigma \cdot v) e^{-mv^2/kT} v^2 dv}{\int_0^{\infty} e^{-mv^2/kT} v^2 dv}$$

Definition by  
an equation

The ion with the mass  $m_2$  has the velocity  $v$  relative to the target ion of mass  $m_1$ . The reduced mass  $m$  of the ion pair is  $m = m_1 m_2 / (m_1 + m_2)$ .

**REACTION Coding:** (... ,SGV, ,MXW)

EXFOR  
REACTION code

**Units:** code from Dictionary 25 with the dimension B\*V (e.g., CM3/SEC).

**Energy Coding:** Data are given as function of the Maxwellian temperature ( $kT$ ), which is coded under the data heading KT with units of energy. See **Spectrum Average** for definition of incident spectrum.



## In this workshop ...

Assignment of the right REACTION code is a most difficult part of EXFOR compilation.

Just copy and paste REACTION code from the article list on the IAEA web site <http://nds.iaea.org/nrdc/india/ws2023/>:

hi		D.Singh (NSD)	Deriv
	Table 3	67-HO-165(10-NE-20,3N)77-IR-182,,SIG	must
			ANAL
			EN,EF

Copy and paste the string  
to the Editor screen.



## Supplemental Numerical Information (Parameters)

$$\sigma = \sigma_M \frac{A \varepsilon_M f_d \lambda_M}{A_M \varepsilon f_d \lambda} \frac{N_M (1 - e^{-\lambda_M t_1}) e^{-\lambda_M t_2} (1 - e^{-\lambda_M t_3})}{N (1 - e^{-\lambda t_1}) e^{-\lambda t_2} (1 - e^{-\lambda t_3})}, \quad (1)$$

Cross section  $\sigma$  depends on the

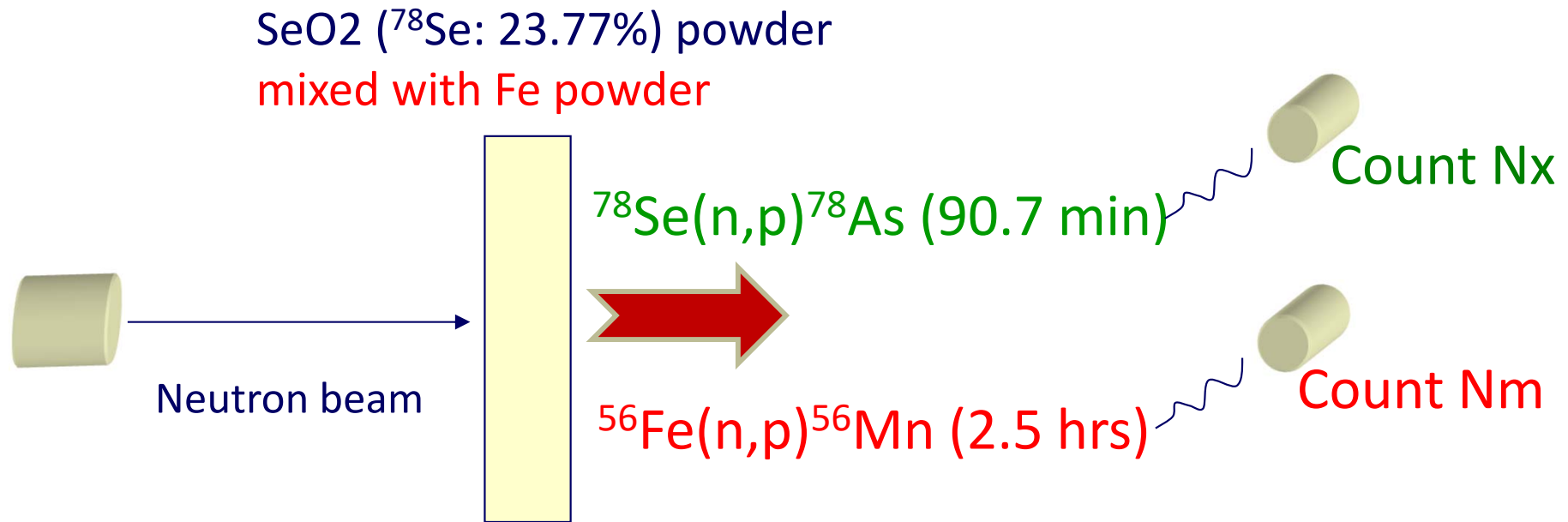
- quantity measured by the authors (count A)

and also depends on values assumed by the authors, for example,

- monitor cross section  $\sigma_M$
- decay gamma intensity f
- decay constant  $\lambda$ .

These assumed values (parameters) are usually taken from the literature. They must be compiled as supplemental information.

# Adopted Monitor Cross Section (EXFOR 33080.002)



Cross section of interest  $\sigma_x = C \cdot (N_x/N_m) \sigma_m$  (monitor cross section)

**MONITOR** (26-FE-56 (N, P) 25-MN-56 , , SIG)  
**MONIT-REF** ( , A. A. Filatenkov+ , R, RI-252 , 1999)

<sup>56</sup>Fe(n,p)<sup>56</sup>Mn cross section reported by Filatenkov in 1999 is adopted. Its value is not reported in the 33080 article.



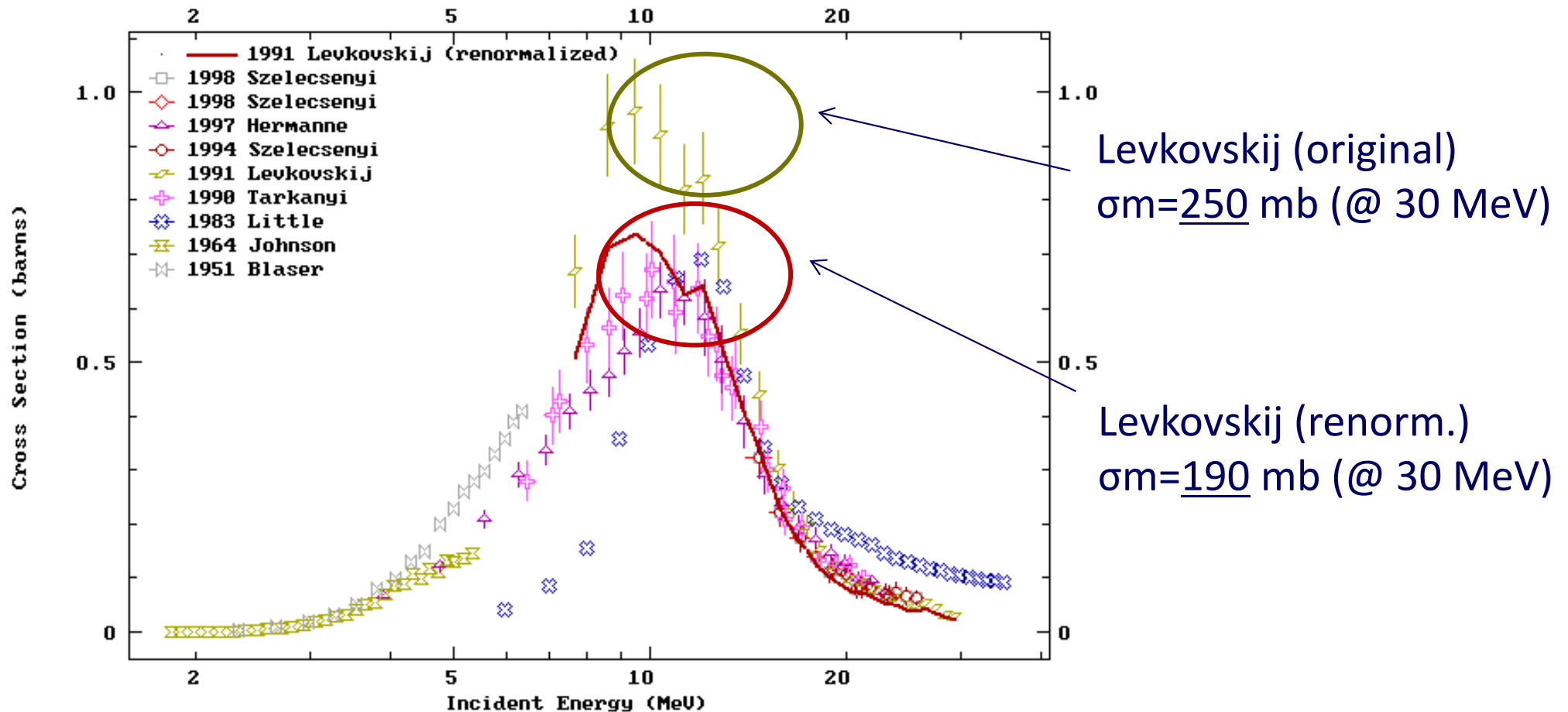
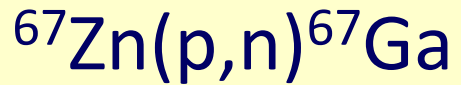
# Monitor Cross Section (EXFOR A0510)

ENTRY	A0510	20110726		A0510000	1
SUBENT	A0510001	20110726		A0510001	1
BIB	12	35		A0510001	2
TITLE	Activation cross section nuclides of average masses (A=40-100) by protons and alpha-particles with average energies (E=10-50 MeV).			A0510001	3
				A0510001	4
				A0510001	5
AUTHOR	(V.N.Levkovskij)			A0510001	6
...					
MONITOR	(42-MO-0 (A,X) 44-RU-97, , SIG)			A0510001	29
	((MONIT) 42-MO-0 (P,X) 43-TC-96, , SIG)			A0510001	30
...					
ENDBIB	35			A0510001	38
COMMON	4	3		A0510001	39
EN-NRM	MONIT	MONIT-ERR	DATA-ERR	A0510001	40
MEV	MB	MB	PER-CENT	A0510001	41
30.	250.	10.	10.	A0510001	42
ENDCOMMON	3			A0510001	43
ENDSUBENT	42			A051000199999	

Mo(p,x)<sup>96</sup>Tc cross section=250 mb at Ep=30 MeV assumed.



# Impact of Monitor Cross Section Update



Monitor cross section adopted by Levkovskij (1991) recorded in EXFOR allows us renormalization with a modern monitor value (factor 0.75!!)

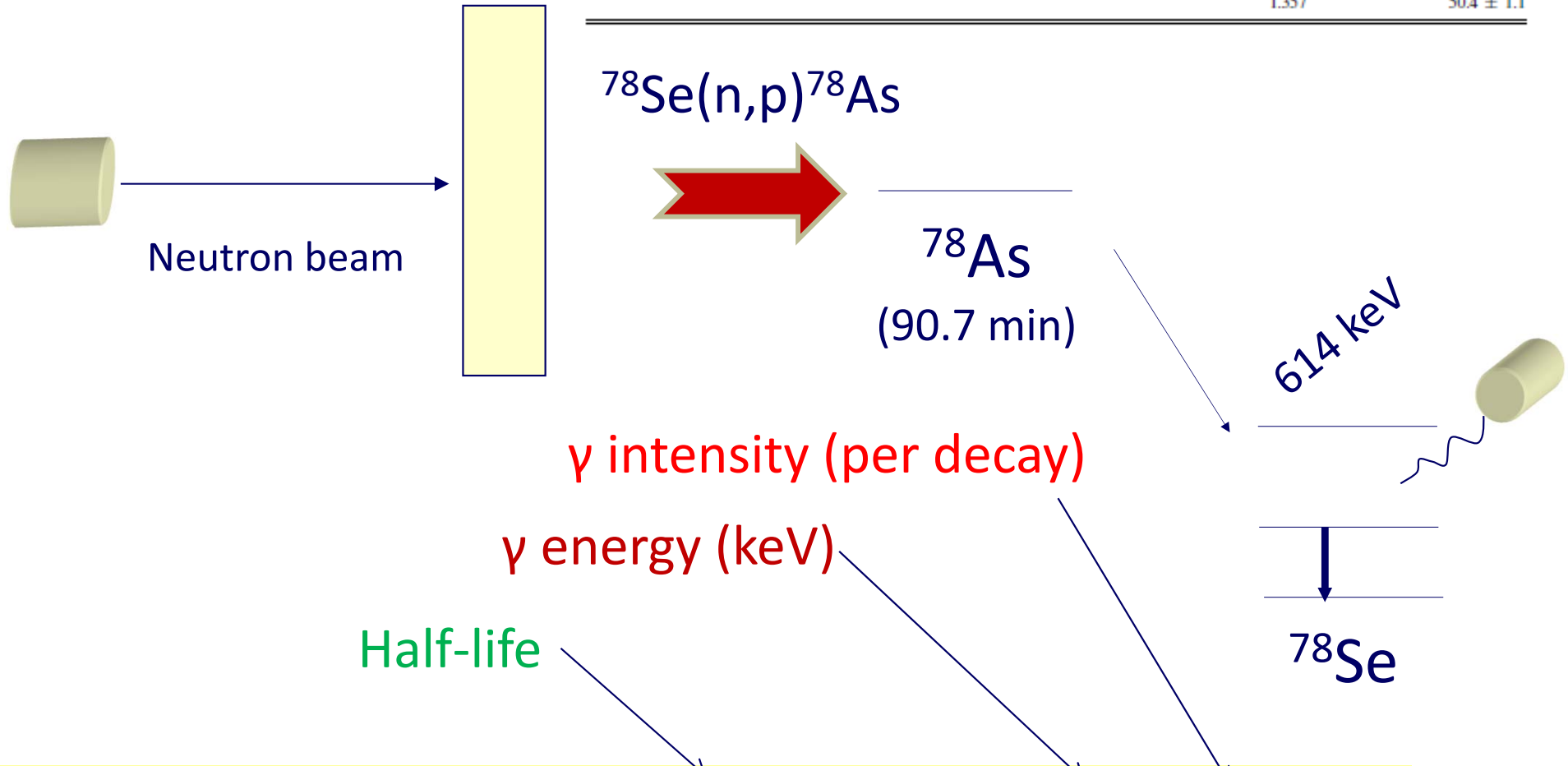


# Adopted Decay data (EXFOR 33080.002)

TABLE I. The decay data of the radioisotopes produced in neutron induced reactions [9–11].

Nuclear Reaction	Abundance (%)	Half life	$E_\gamma$ (MeV)	$f_\gamma$ (%)
$^{78}\text{Se}(n, p)^{78}\text{As}$	$23.77 \pm 0.28$	$90.7 \pm 0.2$ m	0.614	$54 \pm 0.6$
$^{80}\text{Se}(n, p)^{80}\text{As}$	$49.61 \pm 0.41$	$15.2 \pm 0.2$ s	0.666	$42 \pm 0.5$
$^{56}\text{Fe}(n, p)^{56}\text{Mn}$	$91.75 \pm 0.36$	$2.578 \pm 0.0001$ hr	0.847	$99 \pm 0.3$
$^{19}\text{F}(n, p)^{19}\text{O}$	100	$26.91 \pm 0.08$ s	0.197	$96 \pm 2.1$
			1.357	$50.4 \pm 1.1$

c.f. Table I of the 33080 article

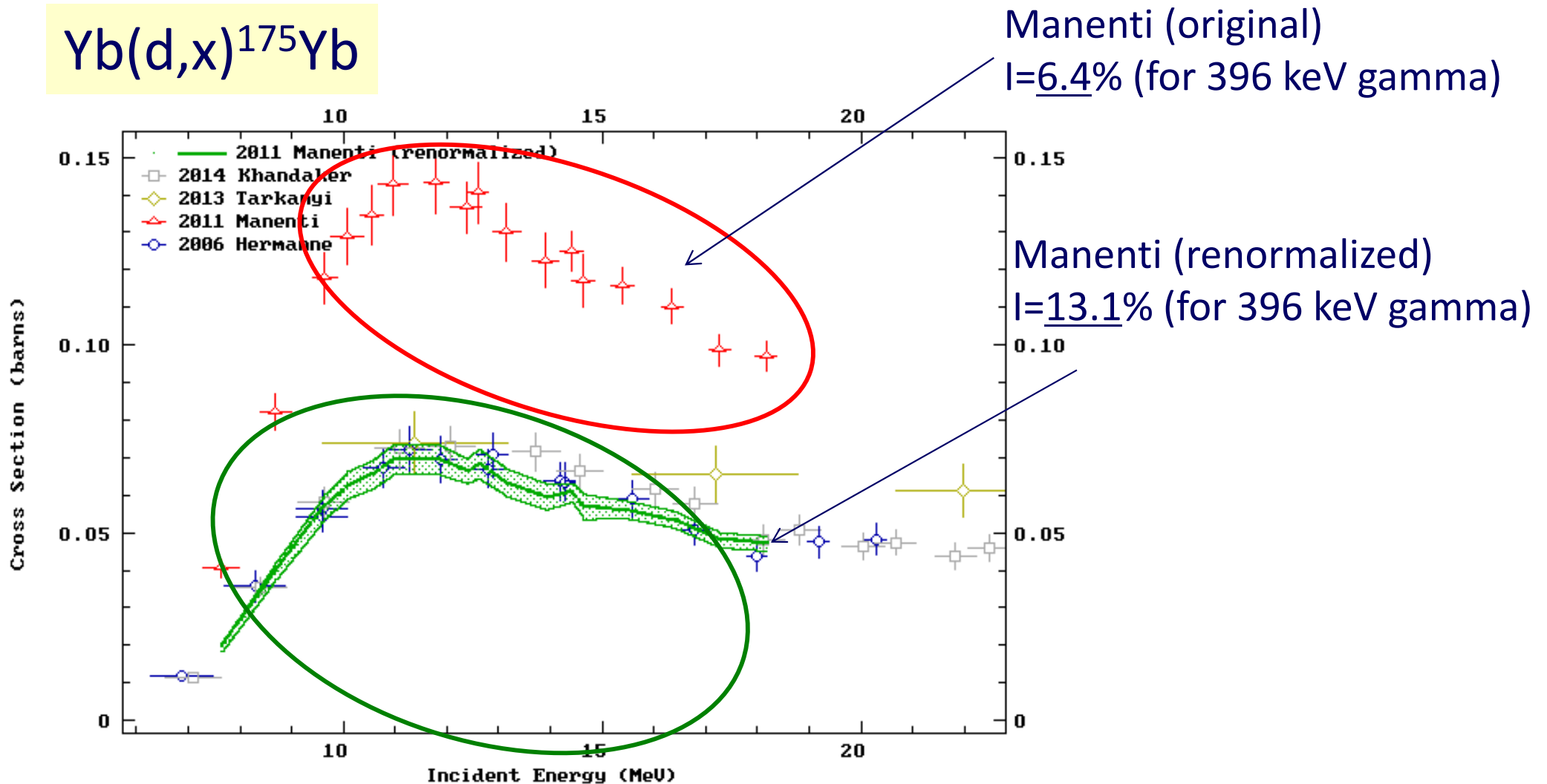


DECAY-DATA (33-AS-78, 90.7MIN, DG, 614., 0.54)



# Impact of Decay Gamma Intensity

$Yb(d,x)^{175}Yb$



gamma intensity adopted by Manenti (2011) recorded in EXFOR allows  
Us renormalization with a modern monitor value (**factor 0.49!!**)



# Uncertainty

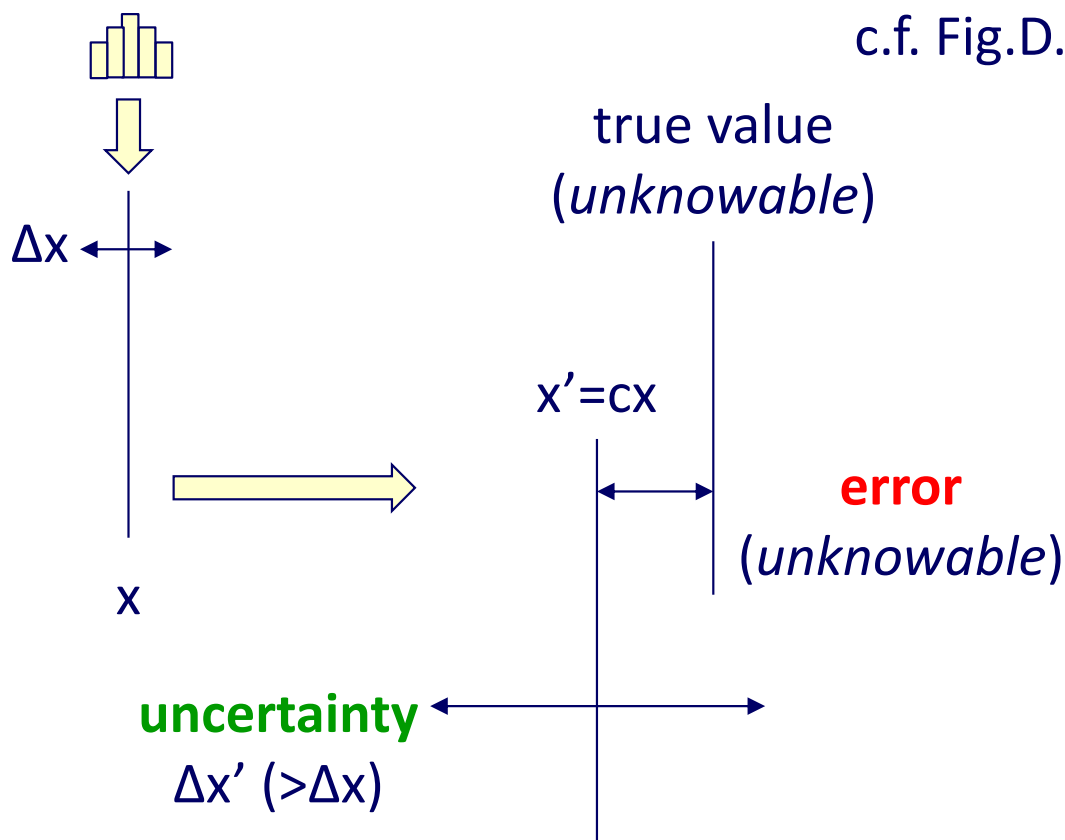
c.f. Fig.D.2 of GUM2008

Measurements

Arithmetic mean  
(not very common  
In ND experiment)

Correction

Result



The true value is within the uncertainty.  
(successful estimation)

Don't mix up "uncertainty" and "error". Experimentalists can report "uncertainty", but cannot report "error" which is **unknowable!!**



# Sources of Uncertainties (Example)

- **Uncertainty independently applied to each data point**
  - Counting statistics
- **Uncertainty commonly applied to each data point (pt)**
  - Unc. due to sample thickness (if the same sample is used for all pts.)
  - Unc. due to gamma intensity (if the same gamma line is used for all pts.)
  - Unc. due to efficiency curve (if the same gamma line is used for all pts.)



# ERR-ANALYS (33080)

are negligibly small. The estimated errors in the different parameters are as follows; (i) detector efficiency ( $\sim 1.5\%$ ); (ii) self absorption of  $\gamma$  rays ( $< 14\%$ ) [14]; (iii) neutron energy distribution ( $< 1\%$ ); (iv) absolute  $\gamma$ -ray intensity ( $< 2.2\%$ ); (v) reference cross section of the reaction  $^{56}\text{Fe}(n, p)^{56}\text{Mn}$  ( $2\text{--}3.7\%$ ) [15]; and (vi) reference cross section of  $^{19}\text{F}(n, p)^{19}\text{O}$  reaction ( $< 5.28\%$ ) [16].

Source	Uncertainty
Detector efficiency	1.5%
Gamma self-absorption	<14%
Neutron energy distribution	<1%
Gamma-ray intensity	<2.2%

```

ERR-ANALYS (ERR-1)      Detector efficiency      (~1.5%)      3308000100017
                    (ERR-2, ,14.) Self absorption of gamma-rays (<14%) 3308000100018
                    (ERR-3, ,1. ) Neutron energy distribution      (<1%) 3308000100019
                    (ERR-4, ,2.2) Absolute gamma-ray intensity (<2.2%) 3308000100020
...
ENDBIB              19              0              3308000100022
COMMON              1              3              3308000100023
ERR-1
PER-CENT
1.5
                    3              0              3308000100027
  
```

# Conclusion

The following keywords are essential for interpretation of numerical data compiled.

**REACTION:** Definition of the quantity given

**DECAY-DATA:** Decay parameters adopted by the authors

**MONITOR:** Reaction adopted by the author for normalization

**DECAY-MON:** Decay parameters adopted for monitor reaction

**MONIT-REF:** Reference where the authors find the monitor value

**ERR-ANALYS:** Definition of total and partial uncertainties





## EXFOR Format

1. Experimental Description

**2. Numerical Description**



# COMMON and DATA Section

Headings and units			66	80
COMMON	1	3	D6213	2 10
E-LVL			D6213	2 11
MEV			D6213	2 12
0.0			D6213	2 13
ENDCOMMON	3	0	D6213	2 14
DATA	3	22	D6213	2 15
ANG-CM	DATA-CM	DATA-ERR	D6213	2 16
ADEG	MB/SR	MB/SR	D6213	2 17
...				
74.76	0.327	0.023	D6213	2 24
80.18	0.258	0.024	D6213	2 25
85.53	0.171	0.018	D6213	2 26
90.01	0.153	0.016	D6213	2 27
...				
ENDDATA	24	0	D6213	2 40
...				

COMMON section (constants of the data set)

Headings and units

DATA section (variables of the data set)



# DATA Section

	11	22	33				
COMMON		1	3		$E_{\text{level}}$	$\theta_{\text{cm}}$	$d\sigma/d\Omega$
E-LVL					(MeV)	(deg)	(mb/sr)
MEV							$\Delta d\sigma/d\Omega$
0.0							(mb/sr)
ENDCOMMON		3	0				
DATA		3	22				
ANG-CM	DATA-CM	DATA-ERR					D6213 2 16
ADEG	MB/SR	MB/SR					D6213 2 17
...							
74.76	0.327	0.023					D6213 2 24
80.18	0.258	0.024					D6213 2 25
85.53	0.171	0.018					D6213 2 26
90.01	0.153	0.016					D6213 2 27
...							
ENDDATA		24	0				D6213 2 40
...							

$E_{\text{level}}$ (MeV)	$\theta_{\text{cm}}$ (deg)	$d\sigma/d\Omega$ (mb/sr)	$\Delta d\sigma/d\Omega$ (mb/sr)
0.0	74.76	0.327	0.023
	80.18	0.258	0.024
	85.53	0.171	0.018
	90.01	0.153	0.016

Each data field has **11** columns.



# “REACTION” and Heading “DATA”

Measured quantities are always coded under the heading DATA.  
Its definition is given under the REACTION code.

...

**REACTION** (91-PA-233 (N, F) , , SIG)

...

<b>EN</b>	<b>DATA</b>	<b>ERR-S</b>	<b>EN-NRM</b>	<b>MONIT</b>
<b>MEV</b>	<b>B</b>	<b>B</b>	<b>MEV</b>	<b>B</b>
11.83	0.8832	0.076	10.50	1.703
12.83	0.8754	0.076	11.50	1.799
13.84	0.8986	0.066	12.51	1.988
14.84	0.9444	0.071	13.51	2.091
15.85	1.1347	0.077	14.52	2.151
16.85	1.4780	0.1	15.52	2.122

