

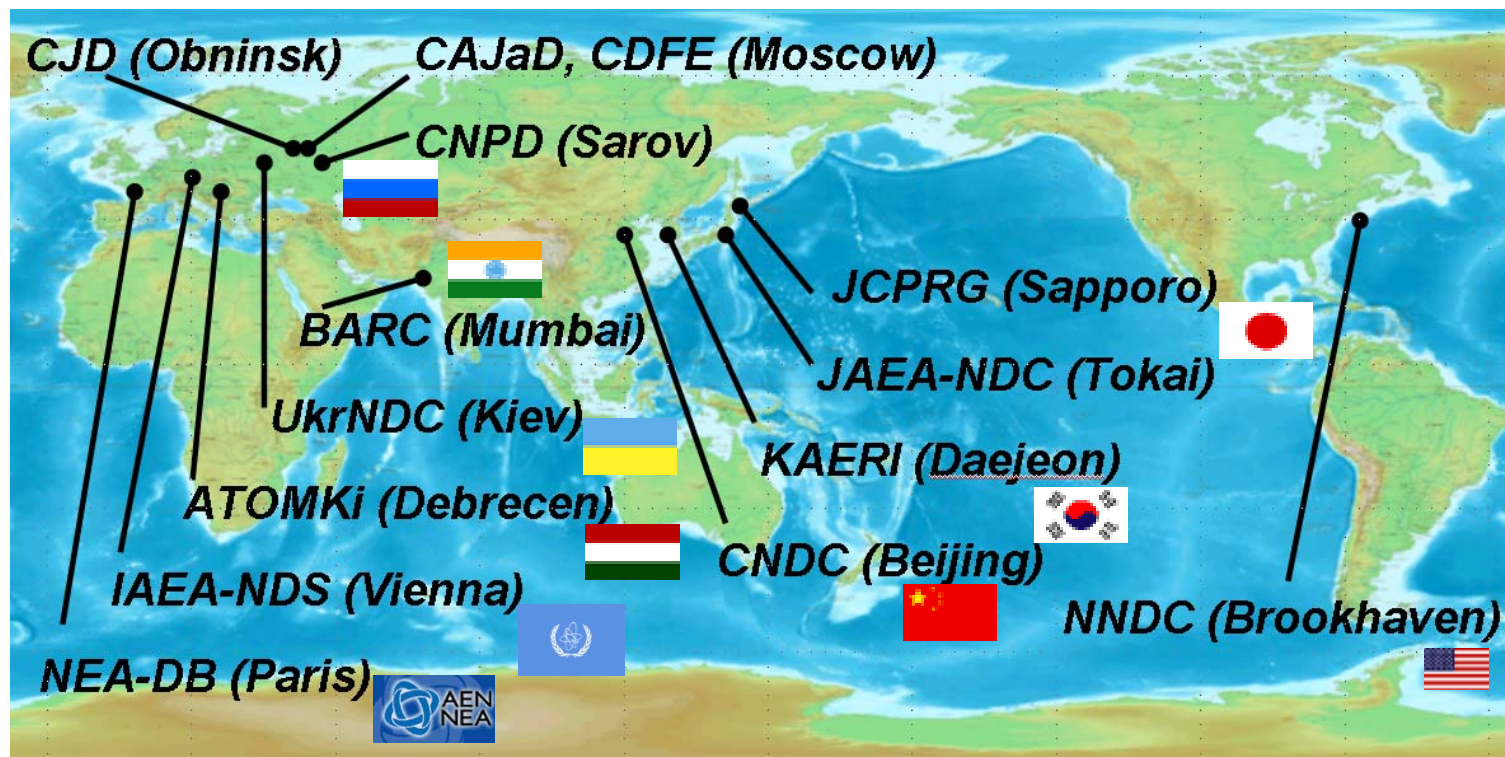


International Atomic Energy Agency

Network Coordination (NRDC)

Naohiko Otsuka, Viktor Zerkin, Lidija Vrapcenjak, Shin Okumura
IAEA Nuclear Data Section

Nuclear Reaction Data Centres (NRDC)



13 centres from 8 countries and 2 international organisations
(China, Hungary, India, Japan, Korea, Russia, Ukraine, USA, NEA, IAEA)

JAEA Nuclear Data Center started EXFOR compilation in 2019!



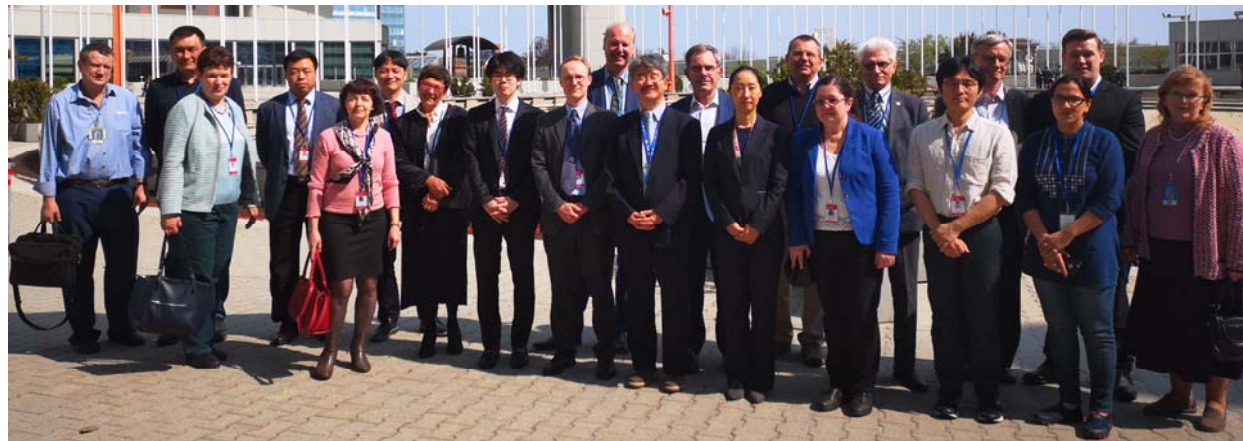
Role of NDS within NRDC

1. Coordination of the EXFOR activity (**NRDC secretary**)
2. Compilation of data from the countries not covered by other centres
 - **Asia** (except for China, India, Korea, Japan)
 - **East Europe** (except for charged-particle data from Hungary)
 - **South America** (with support from **Brett Carlson** for data from **Univ. São Paulo**.)
 - **Africa** (with support from **Deon Steyn** for data from **iThemba Labs**.)
 - **Oceania**



NRDC 2019 Meeting (April 2019, Vienna)

- 16 participants from 12 centres and 2 international organizations
 - 27 conclusions and 78 actions
 - Summary in INDC(NDS)-0792
 - Discussion on
 - retroactive compilation of fission product yields
 - EXFOR Format extension for supplemental information (e.g., neutron source spectrum, resolution function)
- etc.



Chairman: M. Fleming (NEA) / Scientific secretary: N. Otsuka



EXFOR Workshop (October 2018, Vienna)

- 25 participants from 12 countries and 2 international organizations
- 15 presentations (one presentation from the IAEA INIS section)
- Summary in INDC(NDS)-0773
- Training on compilation of **fission product yields**



Chairman: B. Pritychenko (USA)

Rapporteur: S. Okumura and M. Odsuren (Mongolia)

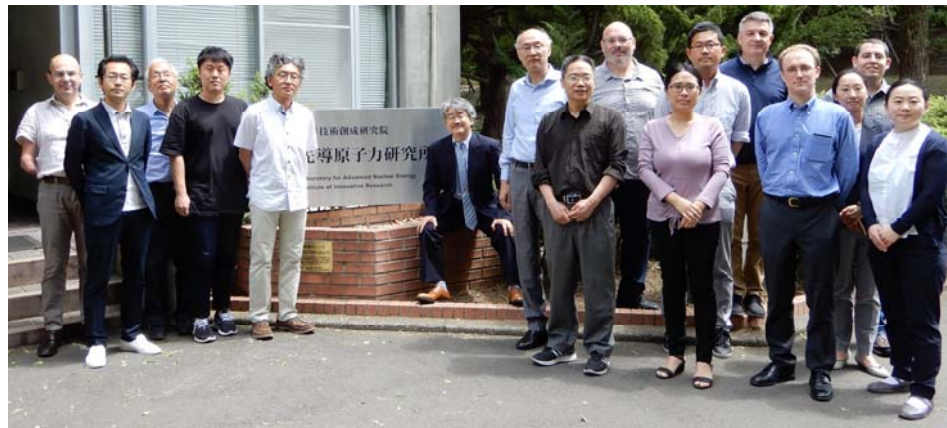
Scientific secretary: N. Otsuka

EXFOR Workshop planned in 2020 was postponed to 2022.



CM on FPY Experimental Database (May 2019, Tokyo)

- 17 participants from 5 countries and 2 international organizations
- 14 presentations
- Summary in INDC(NDS)-0773
- Discussion on
 - EXFOR compilation (coverage etc.)
 - Status of experiment, evaluation, theory and modelling



Chairman: T. Kawano (USA), Rapporteur: M. Fleming (NEA)
Scientific secretary: N. Otsuka



Asian Workshop (AASPP)

- Organized by Four Asian Centres
- EXFOR compilation training and other nuclear reaction database related matters
- Proceedings published in **INDC reports** (since 2013)



AASPP 2019 (Almaty)

2010	Sapporo, Japan
2011	Beijing, China
2012	Pohang, Korea
2013	Almaty, Kazakhstan
2014	Mumbai, India
2015	Sapporo, Japan
2016	Beijing, China
2017	Ulaanbaatar, Mongolia
2018	Gyeongju, Korea
2019	Almaty, Kazakhstan
2020	Mumbai, India (postponed)



Indian EXFOR Compilation Workshop

- Organized by NDPCI, DAE-BRNS and host university
- Lectures and exercises on EXFOR compilation and nuclear data related subjects
- Many Indian articles published in the past two years are compiled during the workshop (e.g., 31 entries in 2019).

2006	Mumbai
2007	Mumbai
2009	Jaipur
2011	Chandigarh
2013	Varanasi
2015	Bangalore
2017	Shillong
2019	Vadodara



2019 Workshop (Univ. of Baroda)



EXFOR Coverage Control

- 53 journals are regularly scanned by NRDC (7 by CNDC, 3 by NNDC, 4 by UkrNDC, 39 by NDS).

The screenshot shows the 'Exfor Work Flow' application window. It has a 'Properties' section with tabs for 'Frag scan' and 'Query'. Below this, there are fields for 'Publication' (PR/C Physical Review, Part C, Nuclear Ph...), 'Comment' (Vol. 65 (2002) -), 'Last Volume' (0), 'Last Issue', and 'Last Scan'. There is also a 'Version' field.

The 'Issues' section contains a table with the following columns: Volume, Issue, Published, Covered, Info, and Comments. The data rows are as follows:

Volume	Issue	Published	Covered	Info	Comments
97	3	01-Mar-2018	01-Apr-2018	<input checked="" type="checkbox"/>	
97	2	01-Feb-2018	14-Feb-2018	<input checked="" type="checkbox"/>	
97	1	01-Jan-2018	02-Feb-2018	<input checked="" type="checkbox"/>	
96	6	01-Dec-2017	11-Dec-2017	<input checked="" type="checkbox"/>	
96	5	01-Nov-2017	30-Nov-2017	<input checked="" type="checkbox"/>	
96	4	01-Oct-2017	31-Oct-2017	<input checked="" type="checkbox"/>	
96	3	01-Sep-2017	18-Sep-2017	<input checked="" type="checkbox"/>	
96	2	01-Aug-2017	28-Aug-2017	<input checked="" type="checkbox"/>	
96	1	01-Jul-2017	17-Jul-2017	<input checked="" type="checkbox"/>	
95	6	01-Jun-2017	14-Jun-2017	<input checked="" type="checkbox"/>	

The 'References' section contains a table with the following columns: Page, Work type, Hierarchy, Laboratory, Quality, Quantity, and Projectile. The data rows are as follows:

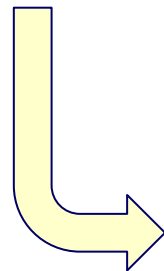
Page	Work type	Hierarchy	Laboratory	Quality	Quantity	Projectile
035806	2 - EXFOR relevant - experimental	3 - Regular publication	2GRCATH - NCSR Demokritos, A...	1 - table	CS - Cross section	cp - charg...
035801	2 - EXFOR relevant - experimental	3 - Regular publication	1CANTMF - Tri University Meson ...	1 - table	RP - Resonance parameter	cp - charg...
034629	2 - EXFOR relevant - experimental	3 - Regular publication	3BZLUSP - Univ.de Sao Paulo, S...	3 - graphic, usefull for digitizing	CS - Cross section	cp - charg...
034618	2 - EXFOR relevant - experimental	3 - Regular publication	1USALAS - Los Alamos National L...	3 - graphic, usefull for digitizing	CS - Cross section	n - neutron
034615	2 - EXFOR relevant - experimental	3 - Regular publication	2GRCATH - NCSR Demokritos, A...	1 - table	CS - Cross section	n - neutron
034612	2 - EXFOR relevant - experimental	3 - Regular publication	2GERGSI - Gesellschaft fuer Sch...	3 - graphic, usefull for digitizing	DE - Differential d/dE'	hi - heavy ...
034607	2 - EXFOR relevant - experimental	3 - Regular publication	3INDTRM - Bhabha Atomic Res. ...	3 - graphic, usefull for digitizing	DAE - Double differential dAngle/dE'	hi - heavy ...
034603	2 - EXFOR relevant - experimental	3 - Regular publication	3INDTRM - Bhabha Atomic Res. ...	3 - graphic, usefull for digitizing	DA - Differential d/dAngle	hi - heavy ...
034320	2 - EXFOR relevant - experimental	3 - Regular publication	2ITYNAP - Dip.di Sci.Fisiche, Uni...	3 - graphic, usefull for digitizing	DA - Differential d/dAngle	cp - charg...
031601	2 - EXFOR relevant - experimental	3 - Regular publication	1USAMSU - Michigan State Unive...	3 - graphic, usefull for digitizing	CS - Cross section	hi - heavy ...

Interface for registration of EXFORable articles (maintained by Marco Verpelli)



Data for EXFOR Compilation with High Priority

- Neutron and charged-particle ($A \leq 12$) induced reaction data (especially those published in new articles)
- Data for specific projects (e.g., fission product yields, isotope production cross sections, thermal neutron scattering)
- Data request from individual users



<https://nds.iaea.org/nrdc/alloc/>

Articles for EXFOR Compilation (Allocation List)
Send your request of compilation















pink: allocated more than 2 years ago. yellow: allocated 1 - 2 years ago. grey: conf. proc. published within 5 years.

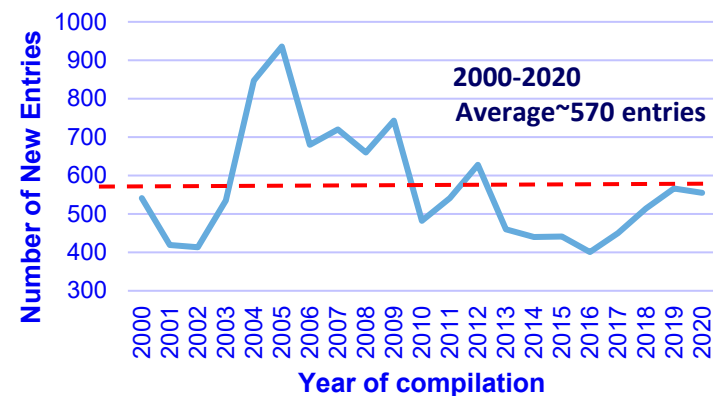
Last updated: 2021-02-24

Entry#	1st author	Reference	Published	Centre	Registered	Memo	Comment
10000	Centre	IAEA-25,205,1975	1975	NNDC	2021-06-15	NR-D/038	Requestor: Stanislav Simakov
10000	L. R. Greenwood	IAEA-31,108,1978	1978	NNDC	2019-08-11		Requestor: Stanislav Simakov
10000	Shimozono	JNM-137,367,1978	1978	IPNS	2019-11-20		Requestor: Stanislav Simakov (1-2021)
92263	E. Gadobek	R. INF/NR-73/5,1973	1973	NEADB	2019-11-22		Requestor: Sergey Kim (DOX tables in IAEA NR-73/5,1973 Entry exists)
10000	Zander	IAEA-173,273,1973	1973	NNDC	2020-06-08		Requestor: Stanislav Simakov
10000	ChCSS	EPJ,178,1584,1990	1990	NNDC	2020-12-20		Requestor: Yashmin Kasib
10000	Demonte	IAEA,137,8115,1993	1993	NNDC	2020-12-23		Requestor: Yashmin Kasib
92285		IAEA,165,118,1971	1971	NEADB	2021-02-07		Requestor: Jilin Wang
92286		IAEA,165,118,1971	1971	NEADB	2021-02-11		Requestor: Stanislav Simakov
10000		C,2006VANCOU,1,(B057),2006	2006	NNDC	2006-11-20		
10000		C,2006VANCOU,1,(C033),2006	2006	NNDC	2006-11-20		



New EXFOR Entries from Centres (2018 – 2020)















Centre	2018	2019	2020
NDS 	79	44	77
ATOMKI 	16	4	8
CDFE 	13	34	12
CJD 	13	24	40
CNDC 	29	18	21
CNPD 	48	31	23
JCPRG 	34	34	21
KNDC 	10	7	2
NDPCI 	23	79	33
NEADB* 	111	108	115
NNDC 	123	120	171
UkrNDC 	15	58	10
KAZMON  	(→NDS)	5	22
Total	514	566	555



* Including JAEA



New EXFOR Entries (3 years) and Backlog

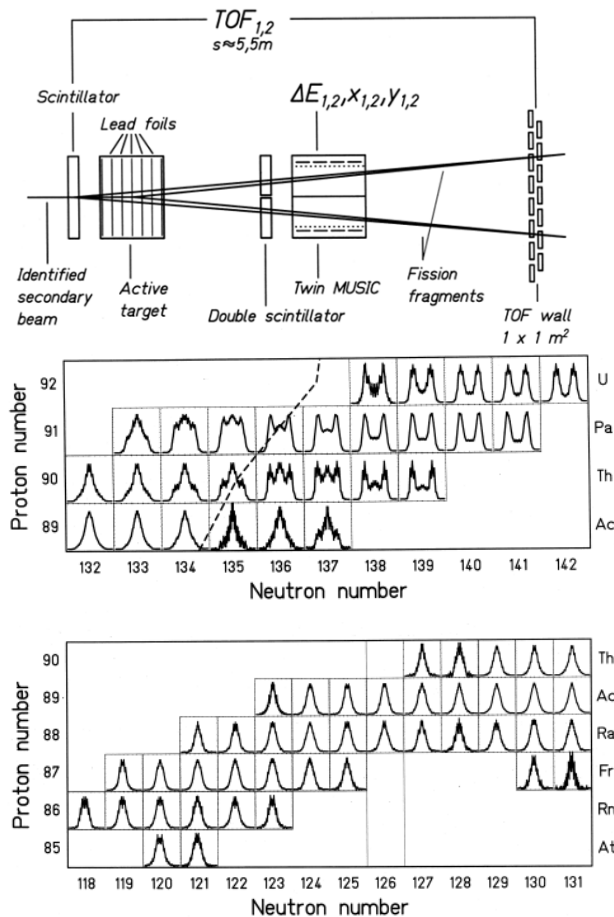
Centre	# of new <i>entries</i> (2018,2019,2020)	# of backlog <i>articles</i> * (1 entry~1.6 articles)
NDS 	200	46
ATOMKI 	28	9
CDFE 	59	20
CJD 	77	20
CNDC 	68	113
CNPD 	102	58
JCPRG 	89	183
KNDC 	19	30
NDPCI 	135	27
NEADB 	334	466
NNDC 	414	652
UkrNDC 	83	8
KAZMON  	27	15
Total	1635	1666

* ~200 backlog articles require further analysis before compilation.



New Entry from NDS: Coulomb Excitation FPY (GSI)

Compilation was postponed for many years due to discussion on the reaction type: heavy-ion induced fission or photo-induced fission?



(γ, f) FPY entries from GSI FRS created in 2020

EXFOR#	target and quantity	Reference
G0074	Ac, Pa, Th FY(Z) and FY(A)	PRC99(2019)054628
G0075	U, Pa, Th, Ac, Ra, Fr, Rn, At FY(Z) and TKE(Z)	NPA665(2000)221
G0076	Th $\nu(Z)$	PRL124(2020)202502
G0077	U FY(Z), FY(A) and FY(A, Z)	PRC95(2017)054603

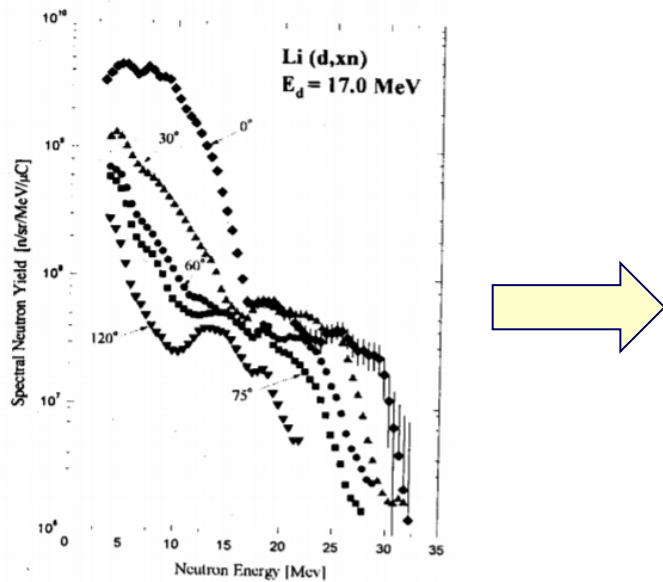


New Entry from NDS: ${}^7\text{Li}(d,n+x)$ Data (NPI, Řež)

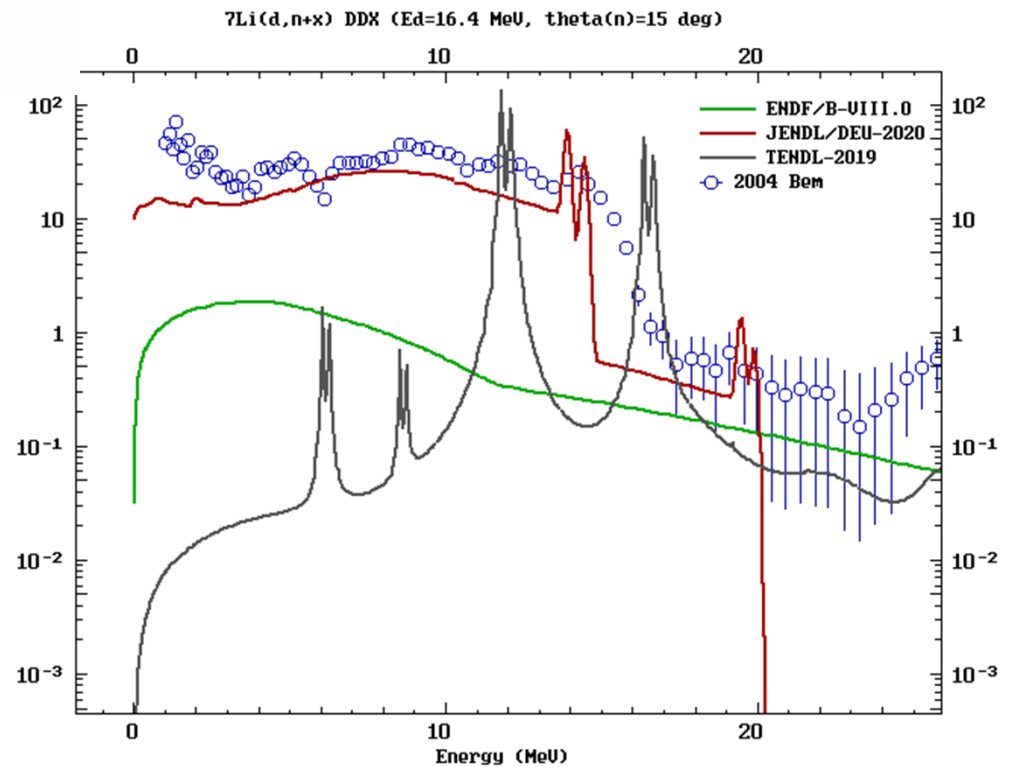
First entry providing the ${}^7\text{Li}(d,n+x)$ absolute energy differential cross section (EXFOR D0976. Data compiled by Stanislav Simakov)

NEUTRON SPECTRA FROM THE $\text{Li}(d,xn)$ and ${}^7\text{Li}(d,n)$ REACTIONS INITIATED BY 16.3 AND 17 MeV DEUTERONS

P. Bém, V. Burjan, M. Götz, M. Honusek, V. Kroha, J. Novák, S.P. Simakov ^{*)} and E. Šimečková,
Nuclear Physics Institute, 250 68 Řež, Czech Republic
^{*)} Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany



$d^2\sigma/dE/d\Omega$ (mb/MeV/sr)



P.Bem et al., ISINN-12,168,2004



Author's Tabulated Data in Archives (ND Archaeology)

INFN/BE-73/5
14 Dicembre 1973

E. Gadioli, I. Iori, N. Molho and L. Zetta: (p, α) REACTIONS ON HEAVY NUCLEI.

The image shows four pages of tabulated data, two for 30 degrees and two for 45 degrees. Each page contains multiple columns of data, including target nuclei (e.g., Ta, Au, Pb, Bi), projectile energy (MEV), and reaction products. The data is presented in a dense, multi-column format typical of scientific publications from that era.

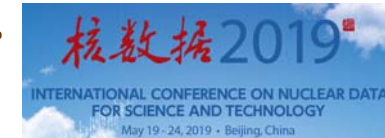
689 18:TA(P+ALPHA) 19.6 MEV						
CH	EN	SIGMA	ERR	CH	EN	S
MEV		MIOR/SR*MEV		MEV		M
6.9		.0	.0	9.2		
9.8		.1	.1	10.1		
10.7		.0	.0	11.0		
11.7		.1	.0	12.1		

- Request from Australia for compilation of Ta, Au, Pb, Bi(p, α) DDX measured by the Milano cyclotron (Gadioli et al., 1973). **Tables in 35 pages. PDF quality was very bad!**
- The requestor sent his hard copy to Vienna. It was forwarded to a NEA DB compiler in Moscow (Svetlana Dunaeva).
- 15,262** data points were added to EXFOR O2263. Released in March 2021!



Intensive Retroactive Compilation of Fission Yields

EXFOR completeness surveys for FPY were performed by NNDC (EXFOR v.s. NSR) and NDS (EXFOR v.s. ENDF+UKFY experimental data citations).



Completeness of neutron-, photo-induced and spontaneous fission yields data

B. Pritychenko^{1,}, O. Schwerer², J. Totans¹, V. Zerkin³, and O. Gritzay²*

¹National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973

²Under contract with National Nuclear Data Center, Brookhaven National Laboratory









³Nuclear Data Section, International Atomic Energy Agency, Wagramer Str. 5, 1220

Completeness of experimental fission product yields in EXFOR database

Takanari Fukuda^{1,2,}, Shin Okumura^{2,†}, and Naohiko Otuka^{2,‡}*

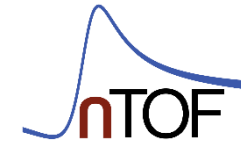
¹Cooperative Major in Nuclear Energy, Graduate School of Advanced Science and Engineering, Waseda University, Tokyo 169-8555, Japan

²Nuclear Data Section, Division of Physical and Chemical Sciences, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, A-1400 Wien, Austria

# of articles	Total	Compiled	Progress (%)
NDS 	47	8	17
CDFE 	35	27	77
CJD 	96	78	81
CNDC 	7	7	100
JCPRG 	5	3	60
NDPCI 	10	10	100
NEADB 	212	81	38
NNDC 	162	91	56
Total	593	296	50

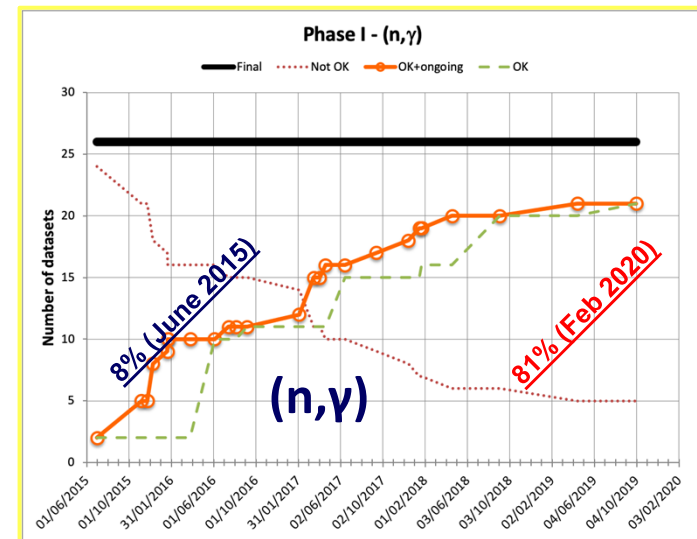


CERN n_TOF – IAEA – NEA Collaboration



- EXFOR is close to complete for n_TOF:
 - 88% for Phase-I (2001-2004)
 - 93% for Phase-II (2009-2012)
 - 100% for Phase-III (2014-2018)
- Iterations with expert users to update the EXFOR entries (e.g., $^{235}\text{U}/^{10}\text{B}$, $^{235}\text{U}/^6\text{Li}$ for IAEA neutron standards).

n_TOF Phase I (2001-2004) data in EXFOR



(courtesy of Emmeric Dupont, n_TOF data dissemination coordinator)

- Similar ongoing collaboration with **GELINA**



EXFOR Quality Assurance by NDS and NEA DB

Newly submitted EXFOR entries are reviewed by NDS and NEA DB.

- Automatic checking by NDS and NEA DB tools (ZCHEX, JANIS)
- Additional checking (format, physics) at NDS
- Additional checking (bibliography, free text, visual inspection) at NEA DB

```
-----File: XX4up00054.txt.err
ZCHEX (Ver-2018-04-20) run on 02-May-2019
-----
Input file: XX4up00054.txt
File labeled: TRANS      1270      980401

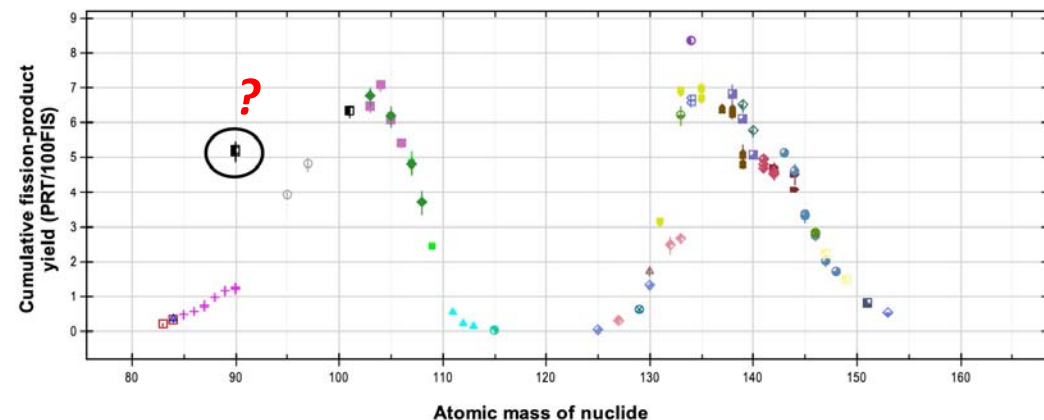
ENTRY 12851
ENTRY 13601
ENTRY 13605
** SUBENT record missing ALTER CODE      13605001
   INSTITUTE (1USAORL,1USAMTS)           13605001000003C
** SUBENT record missing ALTER CODE      13605002
   REACTION (50-SN-124(N,TOT),,SIG)      13605002000003D
ENTRY 13660
** Obsolete BIB Keyword
```

ZCHEX - EXFOR checking code

(V.McLane, BNL(USA), 1998-2001,
V.Zerkin, IAEA-NDS, 2001-2019)

Visual inspection on JANIS (Daniela Foligno, NEA DB)

Incident neutron data / EXFOR / Pu241 / (,F)ELEM/MASS /



Standardization for More Efficient Search

n	Display	Year	Author-1	Energy range, eV	Po
1)	61-PM-148-M(N,G) 61-PM-149,, SIG C4: MF3 MT102				
Quantity: [CS] Cross section					
1	<input type="checkbox"/> + X4 X4+ X4± T4 Cov	1973	G.J.Kirouac+		
2	<input type="checkbox"/> + X4 X4+ X4± T4 Cov	1969	K.Miyano+	2.53e-2	
2)	61-PM-148-M1(N,G),, WID C4: MF=402 MT=6031				
Quantity: [RP] Resonance width					
3	<input type="checkbox"/> + X4 X4+ X4± T4	1973	G.J.Kirouac+	1.69e-1	
3)	61-PM-148-M1(N,G) 61-PM-149,, RI C4: MF=213 MT=102				
Quantity: [RI] Resonance integral					
4	<input type="checkbox"/> + X4 X4+ X4± T4	1962	R.P.Schuman+	5.00e-1	
4)	61-PM-148-M1(N,G) 61-PM-149,, RI,, RNV C4: MF=? MT=?				
Quantity: [RI] Resonance integral, non 1/v part					
5	<input type="checkbox"/> + X4 X4+ X4± T4	1967	N.C.Fenner+	2.00e-1	
5)	61-PM-148-M1(N,G) 61-PM-149,, SIG,, MXW C4: MF3 MT102				
Quantity: [CS] Cross section					
6	<input type="checkbox"/> + X4 X4+ X4± T4 Cov	1967	N.C.Fenner+	2.53e-2	
6)	61-PM-148-M1(N,G) 61-PM-149,, SIG,, SPA C4: MF=3 MT=?				
Quantity: [CS] Cross section					
7	<input type="checkbox"/> + X4 X4+ X4± T4 Cov	1963	C.Mathews+	2.53e-2	
8	<input type="checkbox"/> + X4 X4+ X4± T4 Cov	1962	R.P.Schuman+	2.53e-2	

- Evaluation: N. NICA Publication cut-off: 1-Oct-2013 ENSDF insertion: 2

Nuclide	Energy [keV]	J ^π	T _{1/2} Abund. [mole fract.]	T _{1/2} [s]	Deca BR [%]
¹⁴⁸ ₆₁ Pm	0.0	1-	5.368 d 7	4.64E5 6.05E2	β - 100
^{148m2} ₆₁ Pm	137.9 3	5-,6-	41.29 d 11	3.57E6 9.5E3	β - 9 IT 4

Pm-148 has only one metastable state (41 d).
-M1 must be -M in EXFOR!

(Similar problems exist for In-115 and Eu-152)

Further standardization is important to make EXFOR more searchable.



Two Actions from 32nd INDC Meeting

No.	Respondent	Action
1	NDS	<p>Support international efforts to improve light-nuclide data, <u>including relevant EXFOR compilation</u> and integral experiments.</p> <p>→ No progress for EXFOR compilation. An intensive compilation may be arranged if an article list or data specification (target, projectile, quantity, energy) is given.</p>
6	NDS	<p>Give more priority to the EXFOR compilation of photonuclear data</p> <p>→NDS started compilation of photonuclear data articles when there is a request and/or no responsible centre (e.g., new and old data from European countries like U. Ghent, FZD, GSI)</p>



More about NRDC?

International Atomic Energy Agency
Nuclear Data Services
Section Données Nucléaires, AIEA

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Search

Hot Topics » ENDF/B-VII.1 • TENDL-2014 • JENDL-4.0u2 • IBANDL **News** » Damage cross section database extended by SS-316 and Eurofer

Request
CD/DVD with documentation, data, codes, etc.

Quick Links
ADS-Lib
Atomic Mass Data Centre
CINDA
Charged particle reference cross section
DROSG-2000
DXS
EMPIRE-3.2
ENDF Archive
ENDF Retrieval
ENDF-6 Codes
ENDF-6 Format
ENDVER
ENSDF
ENSDF ASCII Files
ENSDF programs
EXFOR
Electron and Photon Interaction Data
FENDL
Fission Yields

NEW
GRUCON - ENDF Data Processing Package [page]
Prepro-2015 - ENDF/B Pre-Processing Codes [page]
IRDF - International Reactor Dosimetry and Fusion File v1.05 [page]

Main | All | Reaction Data | Structure & Decay | by Applications | Doc & Codes | NDS-Internal | Index | Events | Links | News

EXFOR Experimental nuclear reaction data
LiveChart of Nuclides Interactive Chart of Nuclides
CINDA Nuclear reaction bibliography
ENDF Evaluated nuclear reaction libraries
ENSDF evaluated nuclear structure and decay data (+XUNDL) **
NSR Nuclear Science References

NuDat 2.6 selected evaluated nuclear structure data **
RIPL reference parameters for nuclear model calculations
IBANDL Ion Beam Analysis Nuclear Data Library
Charged particle reference cross section Beam monitor reactions
PGAA Prompt gamma rays from neutron capture
FENDL Fusion Evaluated Nuclear Data Library
Photonuclear cross sections and spectra up to 14 MeV
IRDF International Reactor Dosimetry and Fusion File
NAA Neutron Activation Analysis Portal
Safeguards Data recommendations, August 2008

*Database at the IAEA, Vienna **Database at the US NNDC

IAEA Nuclear Data Section

IAEA-NDS Mission, Staff and more | A+M Atomic and Molecular Data | Meetings Workshops | Newsletters | Coordinated Research Projects | **NRDC** Nuclear Reaction Data Center Network | NSDD Nuclear Structure & Decay Data Network | Technical Documents INDC Reports Publications | Computer Codes

Link to NRDC website

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Last Updated: 15-June-2016 | Web design: V.Zerkin, IAEA, 2016

