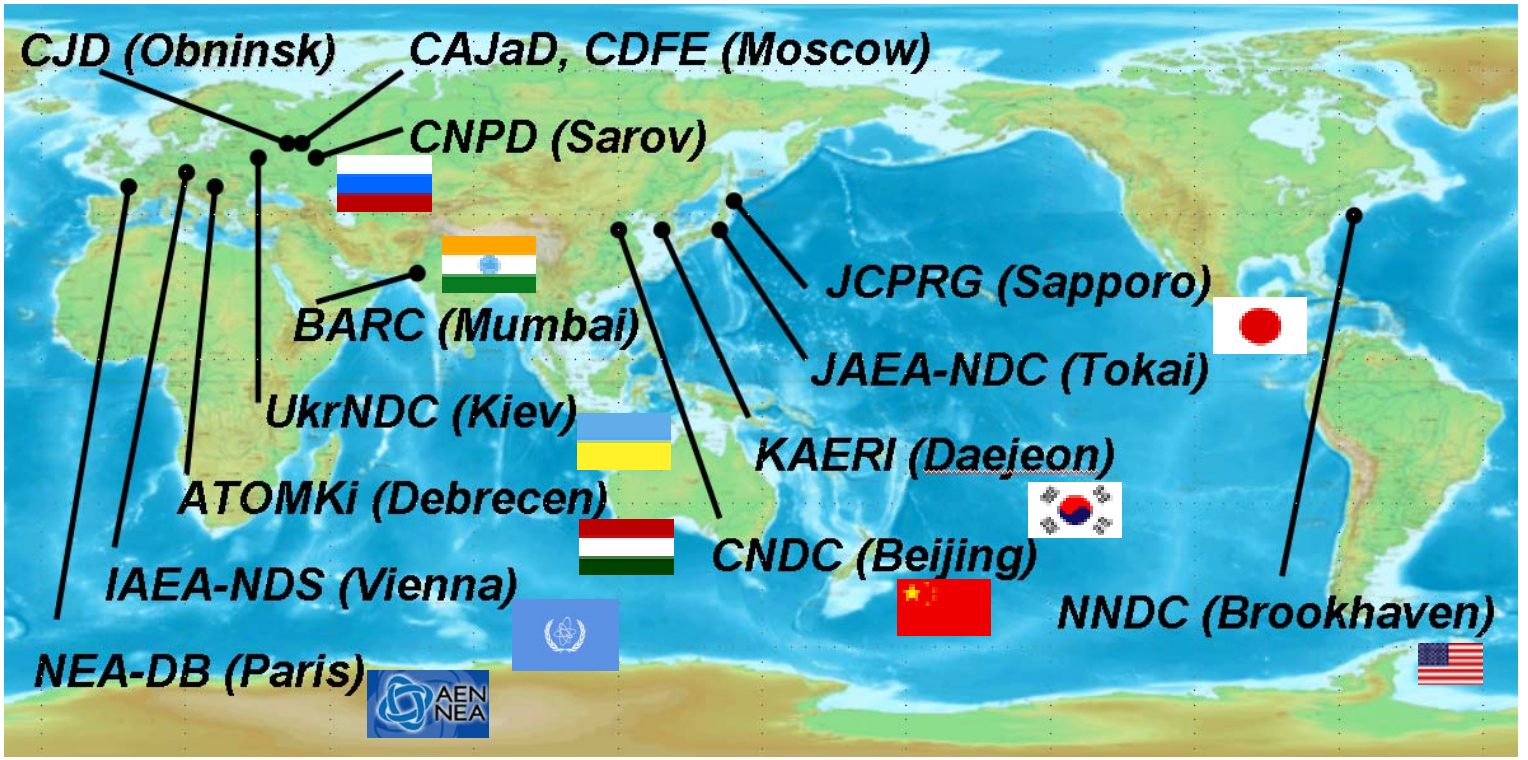
International Atomic Energy Agency

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

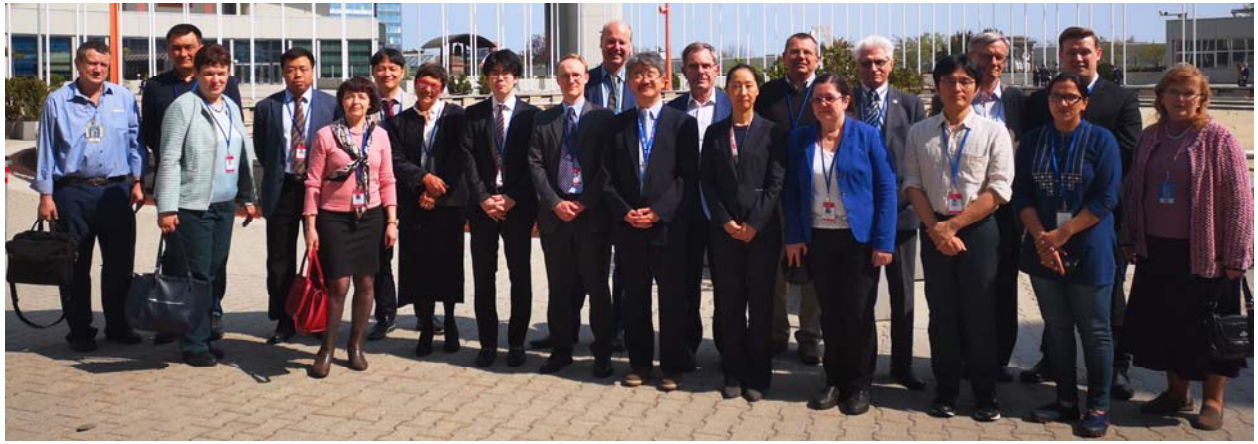
1. Coordination of the EXFOR activity (**NRDC secretary**)

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

NRDC 2020 Meeting +
50th Anniversary of EXFOR Collaboration (Postponed)

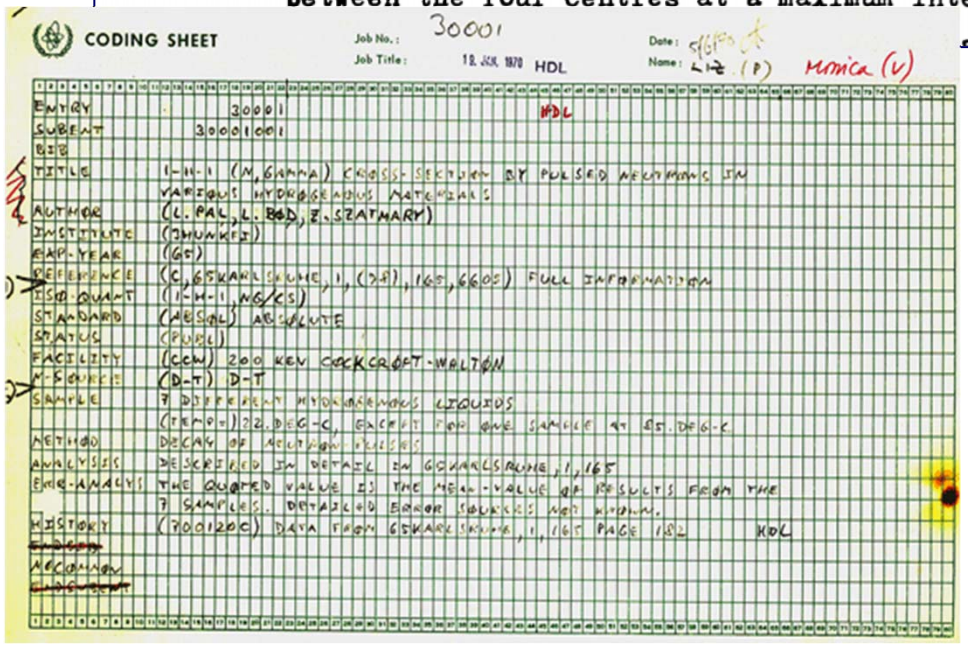
C. IMPLEMENTATION OF EXFOR

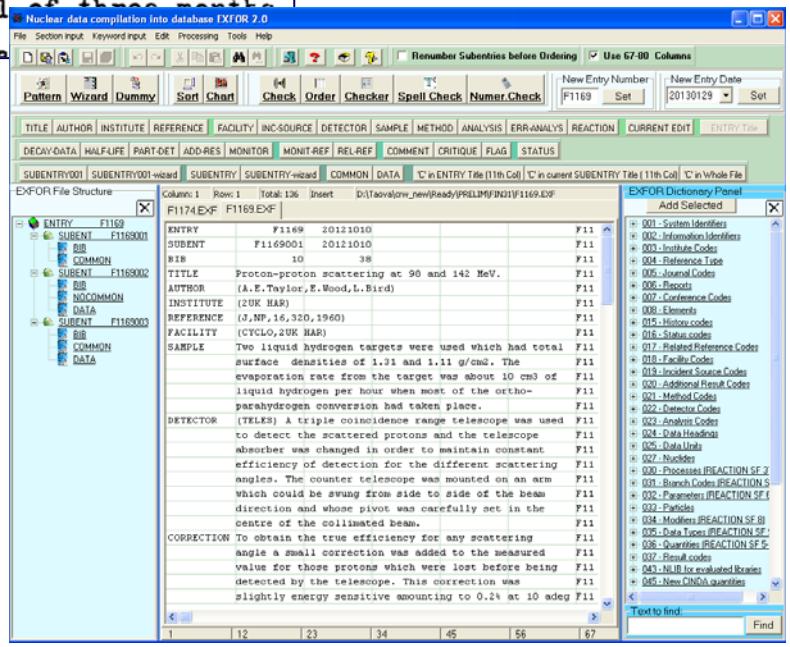
1. Implementation schedule

a) The routine transmission of data tapes in the Exchange Format will start on 1 July 1970.

b) After this date EXFOR data tapes will be exchanged regularly between the four centres at a maximum interval of three months

L.Hjärne,
INDC(NDS)-28 (1970)





Compilation on a coding sheet
(EXFOR 30001 by Hans Lemmel)

Compilation on an EXFOR editor

EXFOR Workshop (October 2018, Vienna)

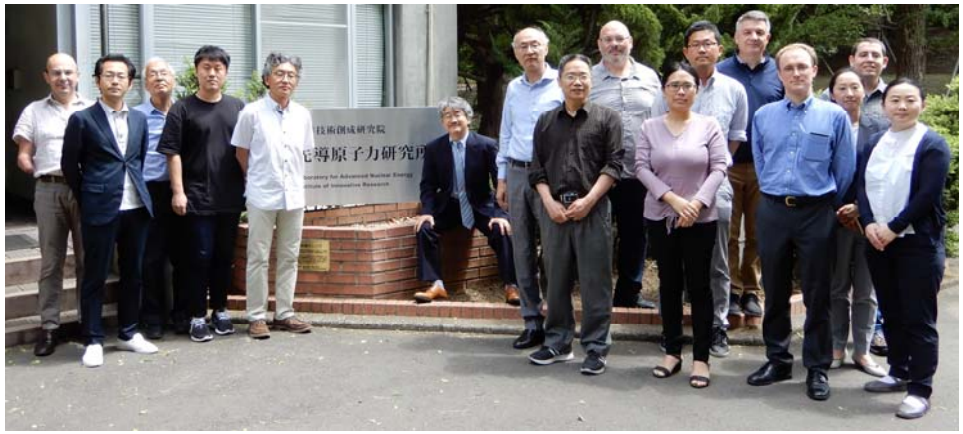
- 25 participants from 12 countries and 2 international organizations
- 15 presentations (one presentation from the IAEA INIS section)
- Summary in INDC(NDS)-0773
- Training on compilation of fission product yields

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)

ડિપાર્ટમેન્ટ ઓફ ફિઝિક્સ ખાતે પ્રથમવાર ન્યુક્લિઅર ડેટા વિશે વર્કશોપ

ન્યુક્લિઅર એ આવનારા સમયમાં એનર્જિ માટે સૌથી મોટો સ્રોત છે: પ્રો.સુરજિત મુખર્જી

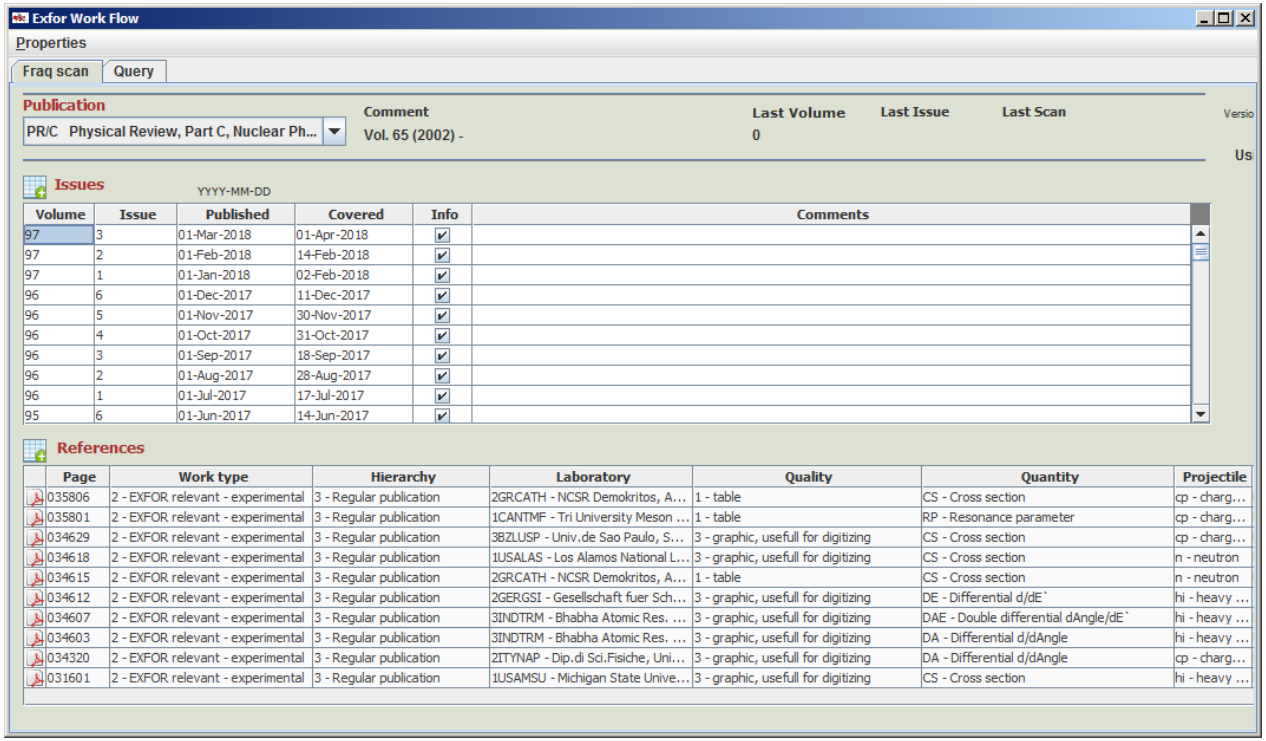
WORKSHOP

વર્કશોપમાં એક્સપર્ટ પણ હાજર રહ્યા.

ન્યુક્લિઅર વર્કશોપમાં 30 વિદ્યાર્થીઓ ઉપસ્થિત

EXFOR Coverage Control

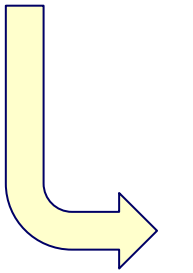
- 53 journals are regularly scanned by NRDC (7 by CNDC, 3 by NNDC, 4 by UkrNDC, 39 by NDS).



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

Data for EXFOR Compilation with High Priority

- Neutron and charged-particle (A≤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

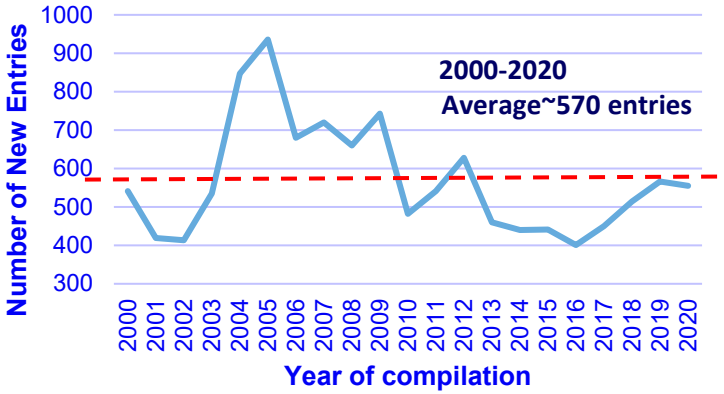
pink: allocated more than 2 years ago. yellow: allocated 1 - 2 years ago. grey: conf. proc. published within 5 years.

Last updated: 2021-02-24

Entry#	1st author	Reference	Published	Centre	Registered	Memo	Comment
10000	Farrar	J,NT,25,305,1975	1975	NNDC	2014-06-16	EP-D/B38	Requestor: Stanislav Simakov
10000	L.R.Greenwood	J,NT,41,109,1978	1978	NNDC	2019-09-17		Requestor: Stanislav Simakov
K2630	Masumoto	J,NIM,157,567,1978	1978	JCPRG	2019-11-26		Requestor: Vladimir Varlamov+EZGT
02263	E.Gadioli+	R,INFN/BE-73/5,1973	1973	NEADB	2019-11-22		Requestor: Sergey Kun (DIX tables in INFN/BE-73/5,1973?) Entry exists
C0000	Zander	J,NP/A,173,273,1971	1971	NNDC	2020-06-08		Requestor: Stanislav Simakov
C0000	GROSS	J,PR,178,1584,1969	1969	NNDC	2020-12-20		Requestor: Yasemin kucuk
C0000	Darmstadt	J,PR,137,B315,1965	1965	NNDC	2020-12-22		Requestor: Yasemin kucuk
02485		J,NP/A,165,118,1971	1971	NEADB	2021-02-07		Requestor: Jimin Wang
02486		J,NCS,9,377,1959	1959	NEADB	2021-02-12		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

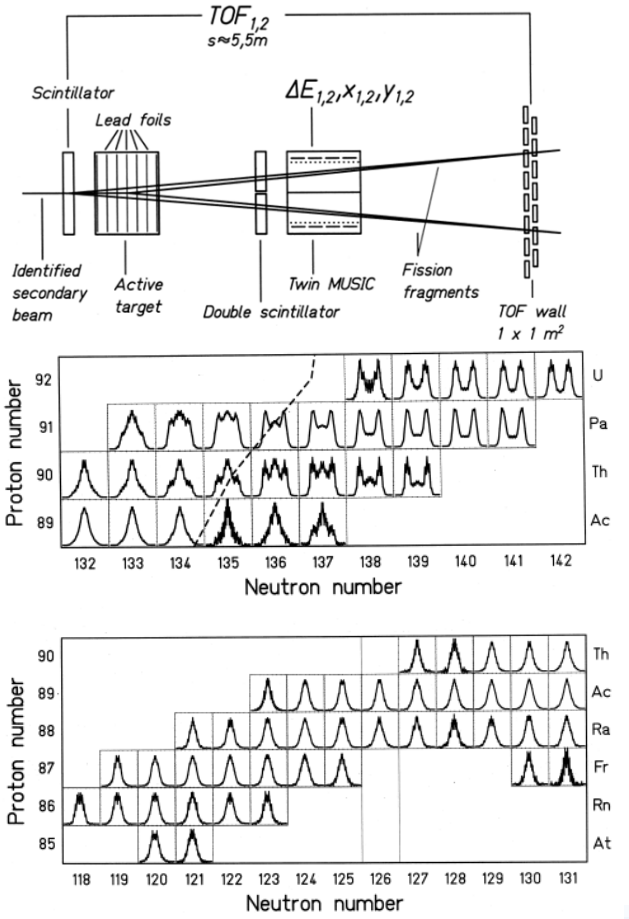
New EXFOR Entries (3 years) and Backlog

Centre	# of new *entries* (2018,2019,2020)	# of backlog *articles** (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?



K.-H.Schmidt et al., NPA665(2000)221

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

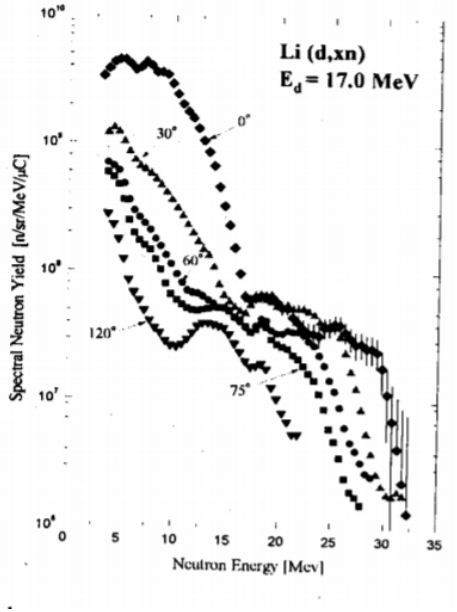
EXFOR#	target and quantity	Reference
G0074	Ac,Pa,Th FY(Z) and FY(A)	PRC99(2019)054628
G0075	U,Pa,Th,Ac,Ra,Fr,Rn,At FY(Z) and TKE(Z)	NPA665(2000)221
G0076	Th ν(Z)	PRL124(2020)202502
G0077	U FY(Z), FY(A) and FY(A,Z)	PRC95(2017)054603

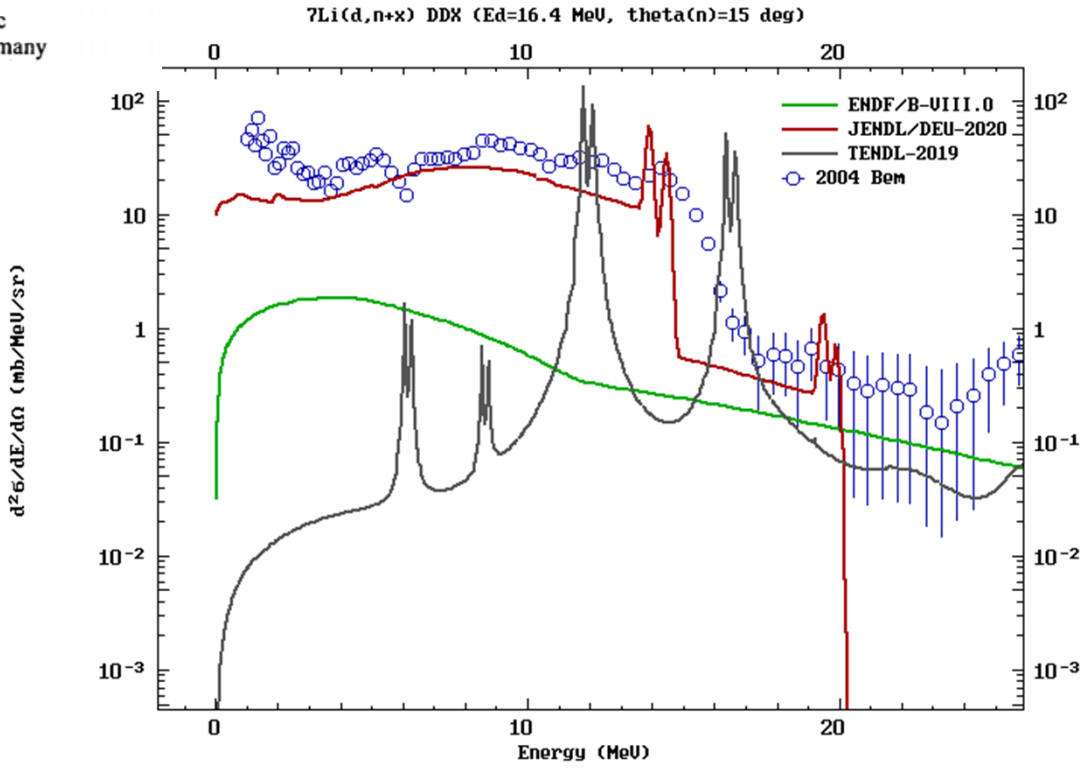
New Entry from NDS: ^{7}Li(d,n+x) Data (NPI, Řež)

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

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

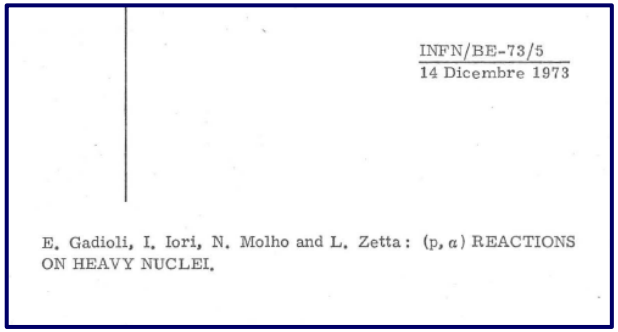
P. Bém, V. Burjan, M. Götz, M. Honusek, V. Kroha, J. Novák, S.P. Simakov [+)] and E. Šimečková,
Nuclear Physics Institute, 250 68 Řež , Czech Republic
[+)] Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany





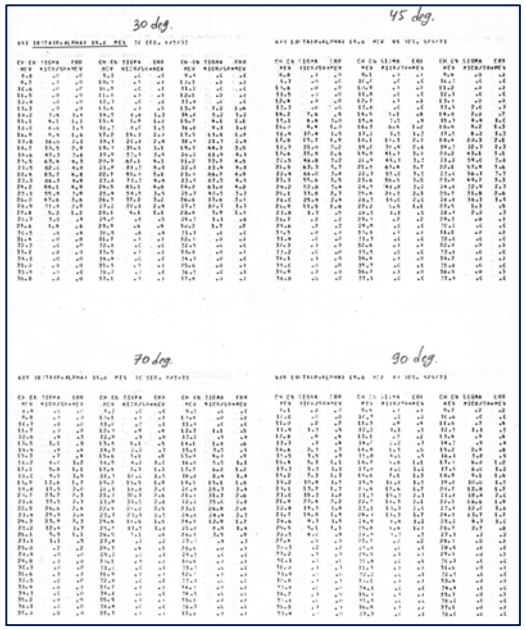
P.Bem et al., ISINN-12,168,2004

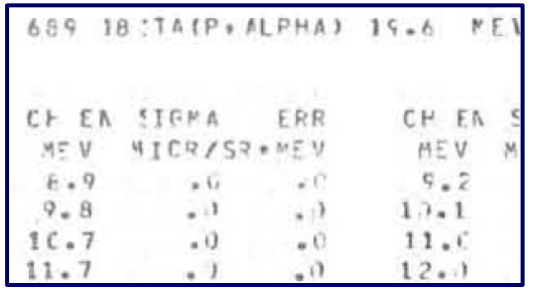
Author's Tabulated Data in Archives (ND Archaeology)



INFN/BE-73/5
14 Dicembre 1973

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





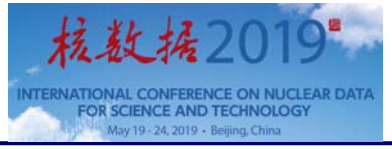
689 18:TA(P,ALPHA) 19.6 MEV

CH EN MEV	SIGMA MICR/SR.MEV	ERR MEV	CH EN MEV
8.9	.6	.0	9.2
9.8	.1	.0	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.* Schwerer[2], *J.* Totans[1], *V.* Zerkin[3], and *O.* Gritzay[2]

[1]National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973
[2]Under contract with National Nuclear Data Center, Brookhaven National Laborato
[3]Nuclear Data Section, International Atomic Energy Agency, Wagramer Str. 5, 122

Completeness of experimental fission product yields in EXFOR database

Takanari Fukuda[1,2,*], *Shin* Okumura[2,†], and *Naohiko* Otuka[2,‡]

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

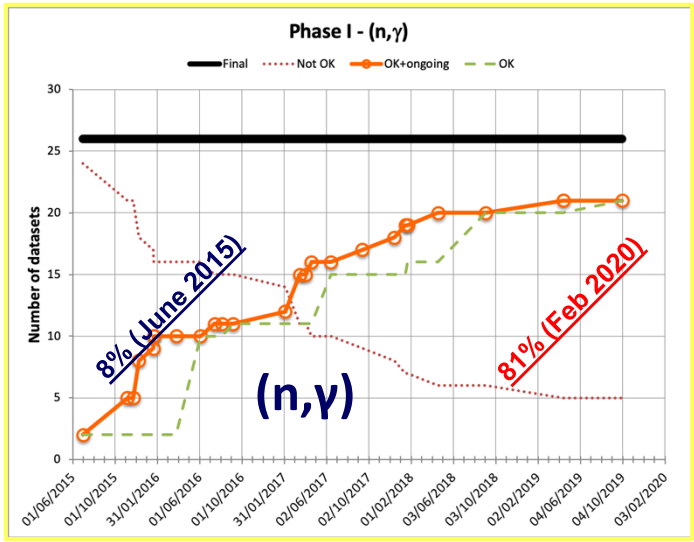
CERN n_TOF – IAEA – NEA Collaboration

- 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., $^{235}U/^{10}B$, $^{235}U/^{6}Li$ for IAEA neutron standards).

- Similar ongoing collaboration with GELINA

n_TOF Phase I (2001-2004) data in EXFOR



(curtesy of Emmeric Dupont,
n_TOF data dissemination coordinator)

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

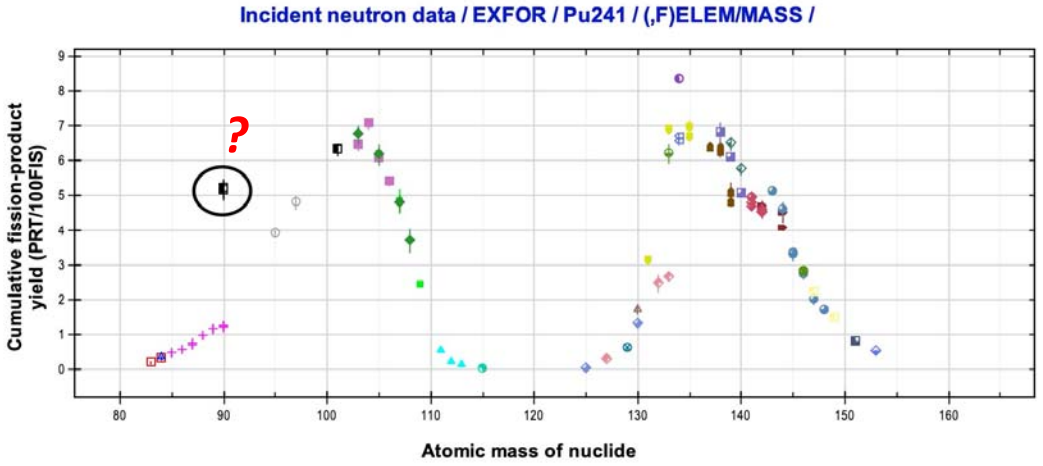
```
------File: XX4up00054.txt.err
 ZCHEX (Ver-2018-04-20) run on 02-May-2019
 ----------------------------------------

 Input file: XX4up00054.txt

 File labeled: TRANS            1270     980401

 ENTRY 12851

 ENTRY 13601

 ENTRY 13605
  **  SUBENT record missing ALTER CODE                          13605001
       INSTITUTE  (1USAORL,1USAMTS)                             1360500100003C
                                                                         ^
  **  SUBENT record missing ALTER CODE                          13605002
       REACTION   (50-SN-124(N,TOT),,SIG)                       1360500200003D
                                                                         ^

 ENTRY 13660
  **  Obsolete BIB Keyword
```

ZCHEX - EXFOR checking code

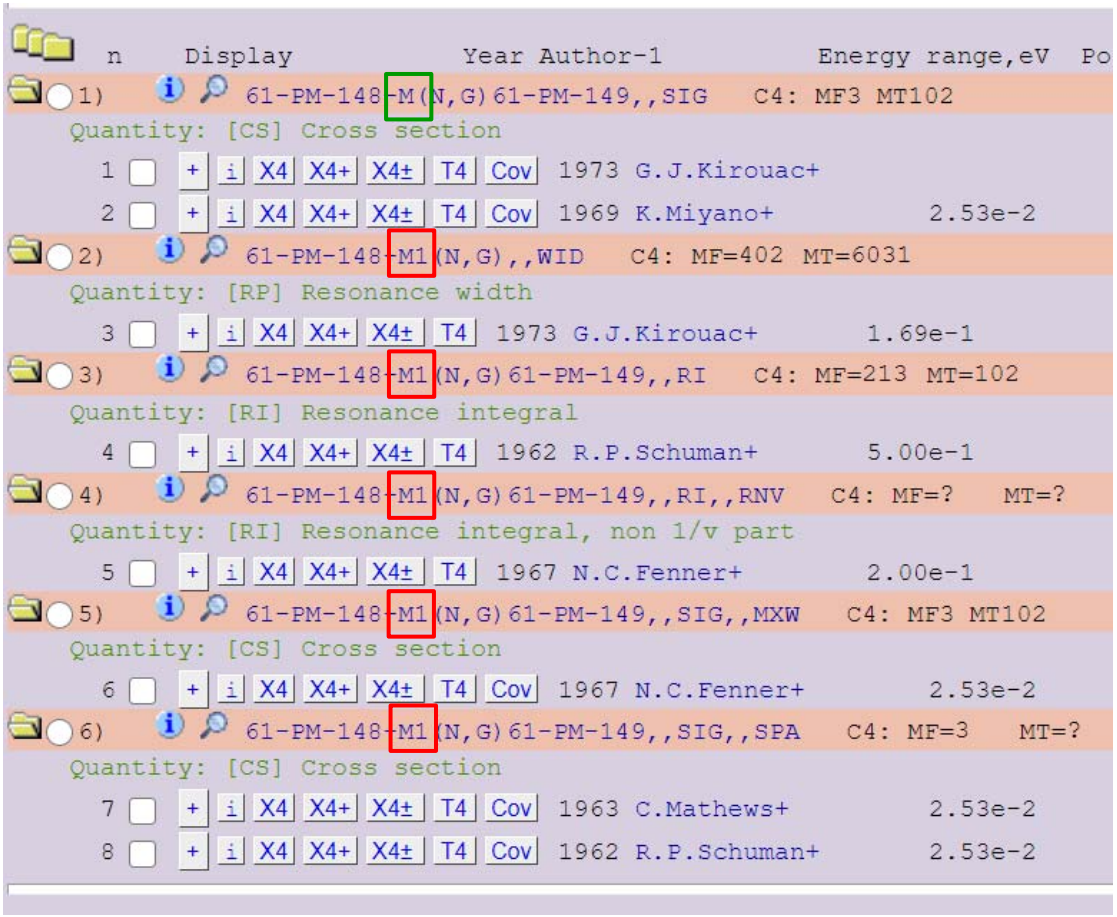
(V.McLane, BNL(USA), 1998-2001,
V.Zerkin, IAEA-NDS, 2001-2019)

Visual inspection on JANIS

(Daniela Foligno, NEA DB)



Standardization for More Efficient Search



· **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 [%
$^{148}_{61}Pm_{87}$	0.0	1-	5.368 d *7*	4.64E5 *6.05E2*	β - 1(
$^{148m2}_{61}Pm_{87}$	137.9 *3*	5-,6-	41.29 d *11*	3.57E6 *9.5E3*	β - IT 9

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	Support international efforts to improve light-nuclide data, including relevant EXFOR compilation and integral experiments. → No progress for EXFOR compilation. An intensive compilation may be arranged if an article list or data specification (target, projectile, quantity, energy) is given.
6	NDS	Give more priority to the EXFOR compilation of photonuclear data →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)

More about NRDC?