



# NSR Tutorial

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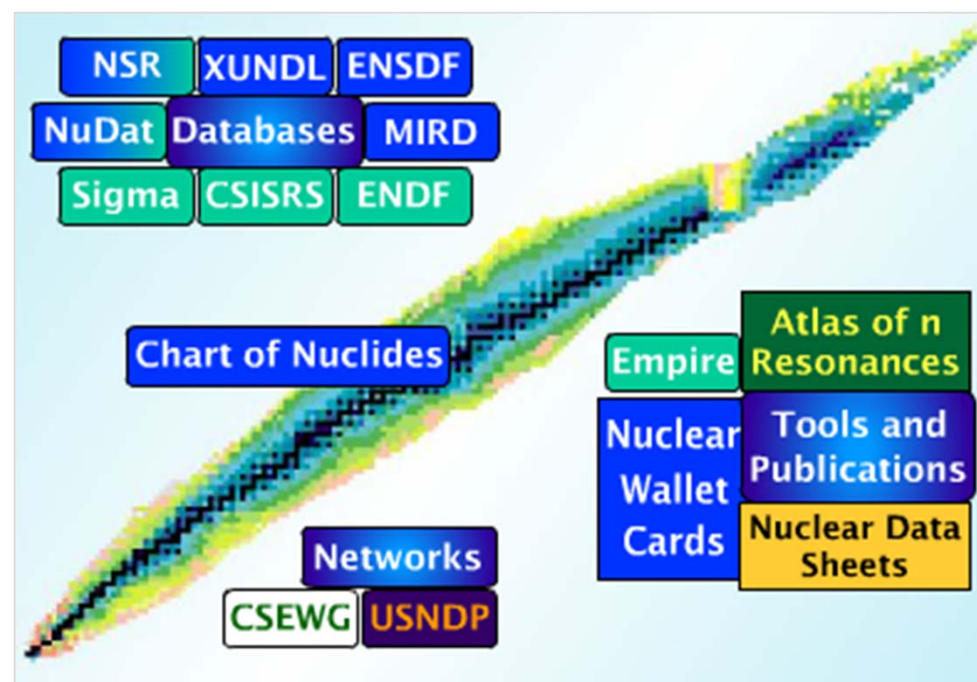


# National Nuclear Data Center

The National Nuclear Data Center (NNDC) collects, evaluates, and disseminates nuclear physics data for basic nuclear research and for applied nuclear technologies. The NNDC is a worldwide resource for nuclear data.

## Major Databases

- ENDF: Evaluated Nuclear (reaction) Data File
- EXFOR: Experimental Nuclear Reaction Data
- ENSDF: Evaluated Nuclear Structure Data File
- XUNDL: eXperimental Unevaluated Nuclear Data List
- NSR: Nuclear Science References



# Nuclear Science References (NSR):

## <https://www.nndc.bnl.gov/nsr>

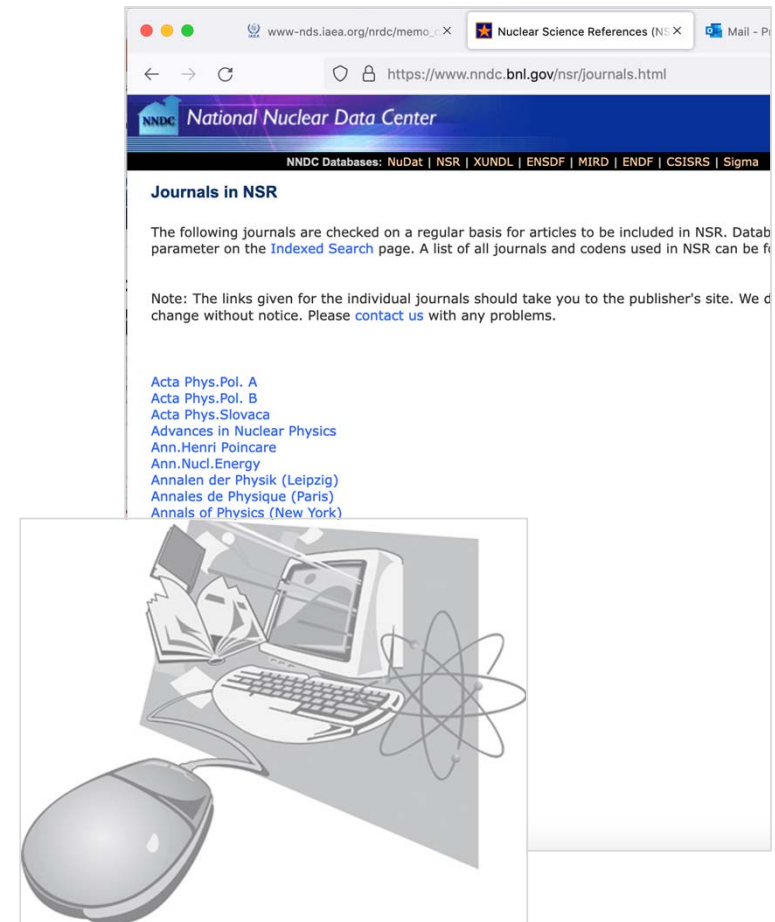
- Katherine Way (formerly at Met Lab, Chicago) recognized the importance of nuclear bibliography database and keywords. She convinced several journals to include keywords (Nucl.Phys., Phys.Rev.).
- Oak Ridge NSR entry consisted of authors, journal and simple nuclear structure keywords; title was often missing.
- References were stored in the ORNL library.
- In 1980 NSR operation was transferred from Oak Ridge to Brookhaven.
- The database was improved at Brookhaven: keywords were expanded, digital object identifiers (doi) and database integration were implemented.



| 648   | BURBIDGE, BURBIDGE,  |
|-------|--|
| Al57a | L. H. Aller, Preprint for <i>Handbuch der Physik</i> (Springer-Verlag, Berlin, 1957).  |
| Al57b | L. H. Aller and J. L. Greenstein (private communication).  |
| Al57c | Aller, Elste, and Jugaku, <i>Astrophys. J. Suppl.</i> 3, 1 (1957).   |
| Al57d | L. H. Aller, <i>Astrophys. J.</i> 125, 84 (1957).  |
| Al50  | R. A. Alpher and R. C. Herman, <i>Revs. Modern Phys.</i> 22, 153 (1950).   |
| Al53  | R. A. Alpher and R. C. Herman, <i>Ann. Rev. Nuclear Sci.</i> 2, 1 (1953).  |
| Ar53  | Arp, Baum, and Sandage, <i>Astron. J.</i> 58, 4 (1953).  |
| Aw56  | M. Amschalom, <i>Phys. Rev.</i> 101, 1041 (1956).  |
| Ba43  | W. Baade, <i>Astrophys. J.</i> 97, 119 (1943).   |
| Ba45  | W. Baade, <i>Astrophys. J.</i> 102, 309 (1945).  |
| Ba56  | Baade, Burbidge, Hoyle, Burbidge, Christy, and Fowler, <i>Publ. Astron. Soc. Pacific</i> 68, 296 (1956).                         |
| Ba57a | W. Baade (private communication).  |
| Ba57  | H. W. Babcock, <i>Proceedings of the Stockholm Symposium on Electromagnetic Phenomena in Cosmical Physics</i> (to be published). |
| Ba50  | C. L. Bailey and W. R. Stratton, <i>Phys. Rev.</i> 77, 194 (1950).   |

# NSR Scope

- Low- and intermediate-energy nuclear physics and selected nuclear engineering publications.
- Journal articles, books, conference proceedings, laboratory reports, theses, private communications.
- Over 80 journals are checked on a regular basis for articles to be included.
- Bibliography of nuclear physics articles, indexed according to content and spanning more than 100 years of research: 242,616 as of May 31, 2022.



# Why do we need NSR???

- NSR was created in support of Evaluated Nuclear Structure Data File (ENSDF) evaluations at Oak Ridge.
- NSR entries are uniquely identified using eight-character strings, NSR keynumbers (i.e. **2012Wa38**, analog of Social Security numbers for nuclear publications).
- NSR preserves the unique set of publications behind each evaluated data set. It makes ENSDF evaluations well-documented and reproducible.
- Entries also include author, journal, title, keywords, doi, EXFOR and XUNDL links.

32Mg<sub>20</sub><sup>-1</sup> From ENSDF - Evaluated August 2011 32Mg<sub>20</sub><sup>-1</sup>

**Adopted Levels, Gammas**

| Type            | Author                          | History | Citation             | Literature Cutoff Date |
|-----------------|---------------------------------|---------|----------------------|------------------------|
| Full Evaluation | Christian Ouellet, Balraj Singh |         | NDS 112, 2199 (2011) | 24-Aug-2011            |

Q( $\beta^-$ )=10270 13; S(n)=5778 5; S(p)=20379 24; Q( $\alpha$ )=-1.455x10<sup>4</sup> 10 **2012Wa38**  
Note: Current evaluation has used the following Q record.  
Q( $\beta^-$ n)=5972 27, S(2n)=8162 22, S(2p)=38530 280 (2011AuZZ).  
Values in 2003A: Q( $\beta^-$ )=10110.00, S(n)=5800.21, S(p)=20000.210, Q( $\alpha$ )=-14620.150, Q( $\beta^-$ n)=5928.27, S(2n)=8187.20  
S(2p)=38630  
Q( $\beta^-$ )=10150 90  
This nuclide is c  
1979Sy01: first  
1983De04, 1984  
1984La03: first  
2004Gr08: <sup>32</sup>Mg  
isotopic half  
2011Ka01: E=9  
Measured in  
model analy  
Mass measure  
RMS radii: 1998  
Yield and cross  
Selected referen  
2005Ro10, 2  
1992Fu07, 1  
Additional info

**NSR Query Results**

Output year order : Descending  
Format : Normal

NSR database version of May 26, 2022.

Keynumber list: '2012WA38'

Found 1 matches.

[Back to query form](#)

**2012WA38** Chin.Phys.C 36, 1603 (2012)

M.Wang, G.Audi, A.H.Wapstra, F.G.Kondev, M.MacCormick, X.Xu, B.Pfeiffer

The AME2012 atomic mass evaluation (II). Tables, graphs and references

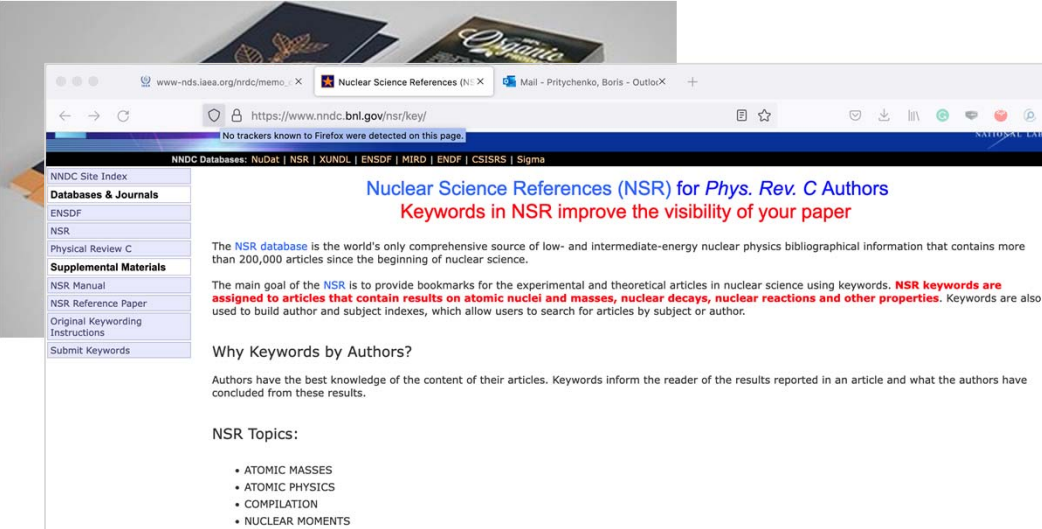
COMPILATION A=1-295; compiled, evaluated atomic mass data.

doi: 10.1088/1674-1137/36/12/003  
Citations: PlumX Metrics

[Back to query form](#)

# NSR Keywords

- NSR provides bookmarks for the experimental and theoretical articles in nuclear science using keywords.
- Articles are keyworded if new results for nuclear reactions, nuclear structure and radioactive decay are published.
- 197,098 NSR abstracts include keywords out of 242,616 NSR entries.



Nuclear Science References (NSR) for *Phys. Rev. C* Authors  
Keywords in NSR improve the visibility of your paper

The NSR database is the world's only comprehensive source of low- and intermediate-energy nuclear physics bibliographical information that contains more than 200,000 articles since the beginning of nuclear science.

The main goal of the NSR is to provide bookmarks for the experimental and theoretical articles in nuclear science using keywords. **NSR keywords are assigned to articles that contain results on atomic nuclei and masses, nuclear decays, nuclear reactions and other properties.** Keywords are also used to build author and subject indexes, which allow users to search for articles by subject or author.

Why Keywords by Authors?

Authors have the best knowledge of the content of their articles. Keywords inform the reader of the results reported in an article and what the authors have concluded from these results.

NSR Topics:

- ATOMIC MASSES
- ATOMIC PHYSICS
- COMPILATION
- NUCLEAR MOMENTS

**2019SP02** Phys.Rev. C 99, 051304 (2019)

M.Spieker, A.Gade, D.Weisshaar, B.A.Brown, J.A.Tostevin, B.Longfellow, P.Adrich, D.Bazin, M.A.Bentley, J.R.Brown, C.M.Campbell, C.Aa.Diget, B.Elman, T.Glasmacher, M.Hill, B.Pritychenko, A.Ratkiewicz, D.Rhodes

*One-proton and one-neutron knockout reactions from  $N = Z = 28$   $^{56}\text{Ni}$  to the  $A = 55$  mirror pair  $^{55}\text{Co}$  and  $^{55}\text{Ni}$*

NUCLEAR REACTIONS  $^9\text{Be}(^{56}\text{Ni}, ^{55}\text{Co})$ ,  $(^{56}\text{Ni}, ^{55}\text{Ni})$ ,  $E=85.9$  MeV/nucleon, [secondary  $^{56}\text{Ni}$  beam from  $^9\text{Be}(^{58}\text{Ni}, X)$ ,  $E=160$  MeV/nucleon primary reaction, followed by separation using A1900 fragment separator]; measured  $E_\gamma$ ,  $I_\gamma$ , partial  $\sigma$ , and parallel momentum distributions using SeGA array for  $\gamma$  detection, and S800 magnetic spectrograph for knockout residues at the NSCL-MSU facility.  $^{55}\text{Co}$ ,  $^{55}\text{Ni}$ ; deduced levels,  $J$ ,  $n$ , mirror energy differences (MEDs) between  $^{55}\text{Co}$  and  $^{55}\text{Ni}$ , configurations. Comparison with large scale shell model calculations.

doi: 10.1103/PhysRevC.99.051304  
Citations: PlumX Metrics

Data from this article have been entered in the EXFOR database. For more information, access X4 datasetC2401. Data from this article have been entered in the XUNDL database. For more information, click here.

# Why do we need keywords???

- Why do we need keywords in the age of Google???
  - Google is a commercial product that is looking for the most frequent (not necessarily nuclear) applications.
  - Google coverage is very good for the last 30 years and problematic with the older unique references.
- Search for  $^{32}\text{Mg}$  nucleus with Google and NSR
  - Google: About 1,160,000 results (0.46 seconds). Impressive but not practical.
  - NSR: 289 articles, easy to deal.

The image shows two overlapping browser windows. The top window is a Google search for '32mg', showing the search bar with the text '32mg' and a magnifying glass icon. The bottom window is the National Nuclear Data Center (NSR) query results page for '32Mg'. The page header includes the NSR logo and the Brookhaven National Laboratory logo. The main content area displays the following information:

- NSR Query Results**
- Publication year range : 1857 to 2022  
Primary and secondary references.
- Output year order : Descending  
Format : Normal
- NSR database version of May 26, 2022.
- Search : Nuclide =  $^{32}\text{Mg}$
- Found 289 matches, compare with [Google Scholar](#). Showing 1 to 100. [\[Next\]](#)
- [Back to query form](#)
- 2022OT01** Phys.Rev. C 105, 014319 (2022)
- [T.Otsuka, N.Shimizu, Y.Tsunoda](#)
- Moments and radii of exotic Na and Mg isotopes*
- NUCLEAR STRUCTURE  $^{21,23,25,27,29,31,33,35,37,39,41}\text{Na}$ ; calculated magnetic dipole and spectroscopic electric quadrupole moments of ground states.  $^{21,23,25,27,29,31,33,35,37,39,41}\text{Na}$ ,  $^{24,26,28,30,32,34,36,38,40,42,44}\text{Mg}$ ; calculated charge and matter rms radii.  $^{27,31,39,41}\text{Na}$ ,  $^{28,32,42,44}\text{Mg}$ ; calculated T plot contours in  $(Q_0, Q_2)$  plane,  $\beta_2$  values. Shell-model calculations with an ab initio effective nucleon-nucleon interaction reported by 2020Ts03: Nature 587, 66 (2020). Comparison with experimental data.

# Example of NSR Indexed Search

- Indexed search is based on NSR keywords.
- NSR indexed search for author Y.Danon, target  $^{56}\text{Fe}$  and deduced cross section value.
- NSR entry includes measured values and not available in the EXFOR database.
- Indeed, NSR contains advanced search options.

The screenshot displays the NNDC website interface for an indexed search. The search criteria are: Author=DANON,Y. AND Target=56FE AND Deduced=SIGMA. The results show one match. The entry details include the publication year range (1857 to 2022), output year order (Descending), and format (Normal). The search results are as follows:

**2017MCZZ** Proc.Intern.Conf.Nuclear Data for Science and Technology (ND2016), Bruges, Belgium, September 11-16, 2016, A.Plompen, et al, Ed. p.11038, (2017);EPJ Web of Conf., Vol.146, Pt.2, 2017

B.McDermott, E.Blain, N.Thompson, A.Weltz, A.Youmans, Y.Danon, D.Barry, R.Block, A.Daskalakis, B.Epping, G.Leinweber, M.Rapp

***$^{56}\text{Fe}$  capture cross section experiments at the RPI LINAC Center***

NUCLEAR REACTIONS  $^{56}\text{Fe}(n, \gamma)$ , E=850-1800 keV; measured reaction products using RPI LINAC C6D6 experimental setup; deduced  $\sigma$ . Compared with other measurements, ENDF/B-VII.1 and JEFF-3.2.

doi: 10.1051/epjconf/201714611038



# NSR was based on NNDC “Paper” Library

- NNDC collects unique references, we acquired Oak Ridge library, Los Alamos, McMaster U. and many other collections.
- NNDC implemented new scanner, microfiche reader, ...
- Joann Totans is leading this effort.
- Traditional “paper” library became a bottleneck due to large volume of requests, and change was needed.
- Electronic library was needed.



# Recovery of NNDC Library Publications

- W.H. Walker private communication to Victoria May.
- EXFOR entry #12127.
- NSR DB entry 1968WEZZ.
- W.N. Wang private communication.
- NSR entry 1968WAZX.
- EXFOR entry 14188, STATUS=CURVE???
- Perhaps, we replace digitization w tabulated data in consultation with Hlavac.
- NNDC Library data processing are in progress.

**1969WAZR** Priv. Co  
W.H. Walker  
reg. Yb and Gd isotopic  
NUCLEAR REACTIONS  $\sigma$ .

| Channel # | 10°       | 20°       | 25°     | 35°    |
|-----------|-----------|-----------|---------|--------|
| 1         | 96 ± 30   | 31 ± 25   | 19 ± 16 | 76 ± 2 |
| 2         | 72 ± 33   | 26 ± 26   | 4.7 ± 4 | 60 ± 2 |
| 3         | 18 ± 23   | 45 ± 30   | 28 ± 16 | 42 ± 2 |
| 4         | 98 ± 28   | 65 ± 22   | 12 ± 11 | 87 ± 2 |
| 5         | 5.7 ± 2.3 | 35 ± 21   | 18 ± 12 | 55 ± 2 |
| 6         | 2.9 ± 2.3 | 6.8 ± 2.4 | 15 ± 11 | 36 ± 2 |

14.1 MeV reaction  
Cu<sup>63</sup> (n, d) Ni<sup>62</sup>

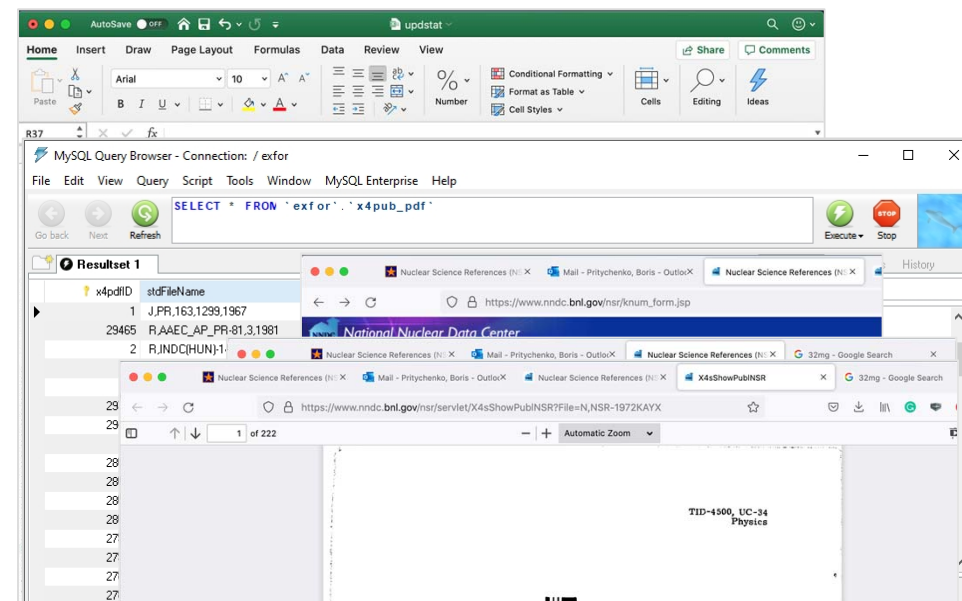
**1968WAZX** Priv. Comm. (1968)  
W.N. Wang  
NUCLEAR REACTIONS  $^{63}\text{Cu}$ ,  $^{58}\text{Ni}$ ,  $^{64}\text{Zn}(n, d)$ , E=14.1 MeV

TELEP ENTRY 14188 20080905 20090306 20090304 1351  
DEEP RIVE SUBENT 14188001 20080905 20090306 20090304 1351  
PETAWAW BIB 11 17  
AREA CC INSTITUTE (ICANM) TITLE n,d reaction studies on Ni58, Cu63, and Zn64  
REFERENCE (T,WALKER) (W,WALKER) AUTHOR (W.N.Wang,E.J.Winhold)  
AUTHOR (W.H.Walker) INSTITUTE (1USARPI)  
TITLE The relative yields of the reaction products (J,PR,140,B882,1965)  
CHALK RIV TITLE The relative yields of the reaction products (J,PR,140,B882,1965)  
Applic dyspros. (REAC) M REFERENCE (CCW)  
INC-SOURCE (REAC) M SAMPLE Self supporting metal foils  $^{58}\text{Ni}$  and  $^{63}\text{Cu}$  with thickness of 3.5mg/cm<sup>2</sup> and  $^{64}\text{Zn}$  with thickness of 2.4mg/cm<sup>2</sup> of isotopis purity greater than 99.8%  
FACILITY (SPECM, REAC,10) DETECTOR (TELES,PROPC,PROPC,SIBAR) Deuterons from the target were detected with a telescope, consisting of two proportional dE detectors and a silicon surface barrier E detector.  
INC-SPECT Reactor METHOD (EDE)  
METHOD Samples (D-T) neutrons with energy of 14.1 MeV  
STATUS (SCSR5) ERR-ANALYS (DATA-ERR) No information given  
HISTORY (19760806) (19821006) HISTORY (20080905C) Compiled by S.H.

ENDBIB 17  
COMMON 1 3  
EN 14.1  
MEV 14.1  
ENDCOMMON 3  
ENDSUBENT 24  
SUBENT 14188002 20080905 20090306 20090304 1351  
BIB 2 2  
REACTION (29-CU-63(N,D)28-NI-62,PAR,DA)  
STATUS (CURVE) Data taken from fig. 6 of the reference  
ENDBIB 2  
COMMON 1 3  
E-LVL  
MEV 0.0  
ENDCOMMON 3  
DATA 3 7  
ANG-CM DATA-CM DATA-ERR  
ADEG MB/SR MB/SR  
9.521E+00 3.332E+00 3.771E-01  
2.005E+01 2.579E+00 2.852E-01  
2.446E+01 1.503E+00 2.116E-01  
3.516E+01 8.871E-01 2.116E-01  
5.041E+01 3.731E-01 1.196E-01

# Complete, Documented Data Sets

- Viktor Zerkin (Nuclear Data Section, IAEA) in collaboration with NNDC started to store PDFs in the EXFOR relational database.
- Data tables are essentially no different than Excel tables: numbers, text, dates and BLOBs.
- Download of the PDF file for Ph.D. Thesis of J.L. Kammerdiener, NSR keynumber = 1972KAYX, works inside BNL or IAEA only.
- Results are described in the Journal of Instrumentation.



**2022ZE01** J.Instrum. 17, P03012 (2022)

[V.V.Zerkin](#), [B.Pritychenko](#), [J.Totans](#), [L.Vrapcjenjak](#), [A.Rodionov](#), [G.I.Shulyak](#)

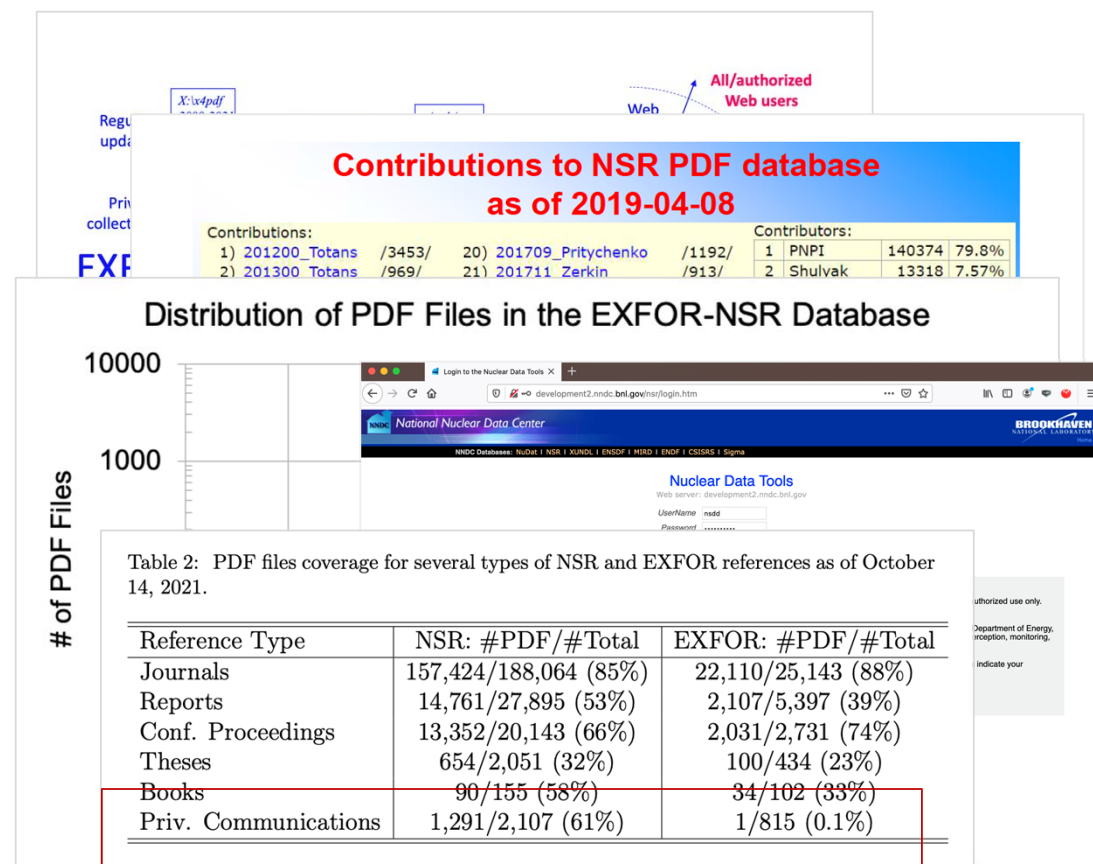
*EXFOR-NSR PDF database: a system for nuclear knowledge preservation and data curation*

doi: [10.1088/1748-0221/17/03/P03012](https://doi.org/10.1088/1748-0221/17/03/P03012)

Citations: [PlumX Metrics](#)

# Portable Document File (PDF) Database

- Portable Document File (PDF) database operation.
- Regular updates of EXFOR and NSR databases extended to PDF files.
- Private collections for existing entries.
- PDF library coverage reflects publishing trends.
- Authorized Web access only due to major publishers restrictions.
- Continuing PDF scanning effort at NNDC.
- Future contributions from LBNL and other labs are more than welcome.



# Takeaways

- NSR is a unique collection of indexed nuclear physics publications that is updated on a weekly basis.
- NSR compilation efforts are complex and well-organized: B. Pritychenko, J. Totans (BNL), B. Singh, D. Symochko (Contractors), V. Zerkin (IAEA).
- NSR abstracts are uniquely identified using the eight-character long NSR keynumbers.
- NSR keywords are essential for indexed search.
- EXFOR-NSR Portable Document File (PDF) database includes 220 K+ files.

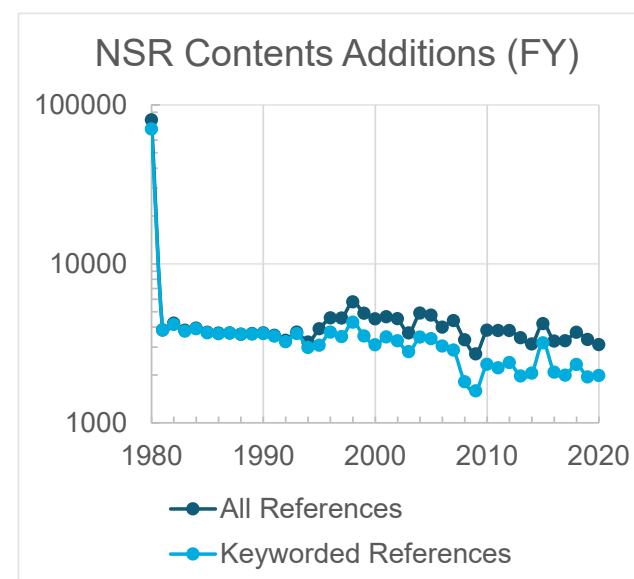


Table 1: PDF coverage for EXFOR and NSR references as of October 14, 2021. Reciprocal PDF contributions are shown as # of complementary files.

| Database | # of References | # of PDF Files | # of Complementary Files |
|----------|-----------------|----------------|--------------------------|
| NSR      | 236,583         | 187,617        | 1,375                    |
| EXFOR    | 34,609          | 26,343         | 1,899                    |
| CINDA    | 39,817          | 14,154         |                          |
| IBANDL   | 795             | 642            |                          |