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EXFOR: General Introduction and Structure

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EXFOR in a nutshell

- Unified computerized system (library and format) by which international, regional and national data analysis centers exchange experimental nuclear reaction data
- Compilation and exchange coordinated by IAEA
- CSISRS = US implementation of EXFOR
- Coverage is complete for neutron data (in particular up to 20 MeV)
- Coverage less complete (but improving) for higher energy neutrons, charged particle-induced and photonuclear data
- More than 60 000 data sets, more than 3 million data points



EXFOR in a nutshell (2)

- Library contains numerical tables and structured abstract with experimental and bibliographic information
- Neutron data: bibliographic link to CINDA (non-neutron data will be added starting 2004)
- EXFOR provides the basis for all nuclear reaction data based applications. But who are its actual users?
 - Evaluators (EXFOR database is starting point for all evaluations)
 - Applied users, if no evaluation available
 - Anybody measuring or calculating reaction data
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Structure of an EXFOR file

- TRANS (center-to-center exchange file)
- ENTRY 1 work, identified by 5-digit accession number (AN)
 - SUBENTRY 1 data table, identified by 8-digit subaccession number (SAN = AN plus 3-digit number 001-999)

Special case: subentry 1: common information for entry

- BIB section: bibliographic and other text information (codes and free text)
- COMMON section: common parameters for entry or subentry
- DATA section: numerical data
- 1 entry has between 2 and 999 subentries
- Subentry 1: BIB section (+optional COMMON section for whole entry)
- Subentries 2-999: BIB section + DATA section (+optional COMMON section for this subentry)



Can you see the punched cards?

- EXFOR format: 80 character ASCII records
- Col. 1-66: contents, format varying depending on record type (e.g. DATA: 6 x 11 character fields)
- Col. 80: Alteration flag
- Col. 67-79: Record identification
 - 67-71 accession number (col.67 alphanumeric)
 - 72-74 subaccession number
 - 75-79 sequence number



System identifiers

• Format:

SYSTEMIDENTIFIER N1 N2 N1, N2 depending on system identifier (date, bookkeeping numbers, added by ORDER)

- TRANS ENDTRANS
- ENTRY ENDENTRY
- SUBENT ENDSUBENT / NOSUBENT
- BIB ENDBIB (NOBIB)
- COMMON ENDCOMMON / NOCOMMON
- DATA ENDDATA (NODATA)



Output formats

- Various output formats (or "user formats") available:
 - Computational formats (for plotting and processing)
 - "Table" format, "Line" format (NNDC)
 - X4TOC4 (by *D.E. Cullen*)
 - ZVView (internal conversion for plotting)
 - "Edited listing" formats (better layout, expansion of abbreviations)
 - XTEND (NNDC)
 - Outdated formats previously used at NDS and other centers
 - Meant for printouts, but could be revived for better electronic output



'REACTION' codes in EXFOR

• Keyword REACTION contains

- actual nuclear reaction observed (subfields 1 4)
- quantity measured (subfields 5-9). Not all subfields need to be present

• Examples:

- (92-U-235(N,F),,SIG) a simple case
- (26-FE-56(N,INL)26-FE-56,PAR,DA,G,LEG/RSD,DERIV) not so simple



Quantities in EXFOR

- Integral and partial cross sections (incl. excitation functions, spectrum-averaged data, ratios etc.)
- Differential cross sections of many types, including angular distributions and Legendre coefficients, secondary particle spectra etc.
- Resonance parameters
- Fission product yields, Nu-bar, fission quantities
- Product yields and thick target yields
- Reaction rates, resonance integrals



A bit of history

- EXFOR = EXchange FORmat
- Started 1970 for neutron-induced reaction data, 1976 extended for CPND and photonuclear data
- Forerunners: NEUDADA (NEA Data Bank), DASTAR (IAEA), SCISRS (old version from USA, covered whole world)
- 1970: Exchange agreement ("Protocol") between 4 "core" centers (NNDC, NEA-DB, IAEA-NDS, CJD) - At that time data exchange between East and West was important function of IAEA
- Today North-South exchange most important
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What's special about EXFOR?

- It's the **compilation philosophy**
- It's work-oriented, not publication-oriented, therefore it is different from most bibliographic systems, not only because it contains numerical data

• 1 entry = 1 experimental work

- This usually corresponds to several (formal and/or informal) references: a progress report, a conference contribution, a laboratory report, a final publication
- All references describing one experimental work are collected first by the EXFOR compiler. The entry then contains the latest available information extracted from all these references (e.g. experimental details from informal report with latest numerical data from final publication)



EXFOR entries are alive!

- When possible, authors are contacted for approval
- Authors are encouraged to submit preliminary data to EXFOR (e.g. by private communication) because updating (with new data and/or new references) is a routine matter
- Even corrections after final publications (possibly published as *"Errata"* which are hard to find in the journals) are no problem
- Conclusion: an EXFOR entry has a value similar to a publication and sometimes is even more up-to-date.
- EXFOR = pre-digested experimental data

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What should we compile?

- Original experimental data
- General priority: low and medium energy (up to 1 GeV), projectiles up to alphas
- Higher energies and heavy ion data may be covered depending on manpower and compatibility with EXFOR format
- Normally not compiled:
 - Data derived from other authors' experiment
 - Theoretical data, evaluated data (only exceptionally)
- Quantities:
 - What's in LEXFOR and/or dictionary 36
 - Also relative data and ratios of reaction quantities



As close as possible to the publication

- EXFOR entries are compiled keeping as much as possible the author's style (representation of data, units, etc.) to
 - enable easy comparison with published reference and
 - help avoiding mistakes in compilation
- Very important: correctly report the reference and standard values the *author* used, do *not* replace with more recent data, so that later renormalisation is possible.
 - Standard cross sections
 - Half-lives, branching ratios! Do not misunderstand EXFOR as a chart of nuclides!
- If compiler believes that the data have a serious problem, this can be entered under keyword COMMENT ("Compiler's comment") or CRITIQUE. Clearly separate compiler's opinion from reporting the author's work.



What numbers to enter

- Try everything to get numerical values from authors
- If graphs have been digitized by you, send entry to authors to encourage them to send original data now
- If graphs are unsuitable for digitizing: compile with NODATA ? ("Unobtainable")
- If ratio to standard is given, compile it



Compilation Flow Chart Part 1







Compilation Flow Chart Part 3







Sharing the work

Compilation

- Neutron data: 4 "core" centers NNDC, NEAD-DB, NDS, CJD, with additional input from China, Ukraine, ...
- CPND: JCPRG, CAJAD, NNDC, ATOMKI, VNIIEF, with additional input by other centers
- Photonuclear data: CDFE and some additional input
- Detailed agreements about exchange of TRANS files, communication of errors, corrections, etc.
- Communication between centers by CP-memos
- EXFOR dictionaries maintained by IAEA-NDS
- EXFOR manuals maintained by NNDC
- Substantial changes in dictionaries or manuals must be approved by NRDCs





- NDS coordinates NRDC, defines core centres, assigns compilation responsibilities, keeps master file
- Core centers decide on compilation rules and new quantities. NDS is final arbiter in case of disagreements on rules or dictionary codes
- All transmission to NDS (open area)
- NDS may do corrections or assign volunteers to do them if a center does not retransmit in timely manner
- Errors found by another center should be communicated to all
- New subdirectory for problematic entries withdrawn from a PRELIM transmission



Compilation responsibilities

 <u>Compilation responsibilities</u> as given in Network document



Urgent compilation needs

- First, request compilation from responsible center with copy to NDS
- If responsible center cannot compile within requested time, you may compile it as Z-entry and send it to responsible center and NDS
- Then either regular compilation by responsible center, or NDS will transmit Z entry to all
- Later transmission by responsible center (and deletion of Z entry) is possible at any time



Literature on EXFOR

- EXFOR Basics, BNL-NCS-63380 (IAEA-NDS-206) (2000), by V. McLane. (Format description for users, available in PDF format from IAEA-NDS web page.)
- EXFOR Systems Manual, BNL-NCS-63330 (IAEA-NDS-207) (2001), ed. by V. McLane. (Format manual for compilers and programmers, available in PDF format from IAEA-NDS web page.) New version: Sept. 2003
- LEXFOR, informal BNL-NCS report (IAEA-NDS-208), ed. by V. McLane (2001) (Compiler's manual including physics definitions, available in PDF format from IAEA-NDS web page.)
- Short Guide to EXFOR, IAEA-NDS-1, Rev.7 (1996) by H.D. Lemmel. (Overview of format, contents and history for users. Description of retrieval interface out of date.)