FPY Data Compilations

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Experimental Nuclear Reaction Data (EXFOR)

- Manhattan Project alumni continued reaction compilations at Brookhaven in early 1950s.
- International cooperation in compilation areas #1, 2, 3 and 4 or NNDC, NEA-Databank Paris, NDS IAEA and IPPE, respectively, since 1969.
- Presently run by the Nuclear Reaction Data Centres (NRDC), internationally. This is an IAEA network which is coordinated by the IAEA.
- EXFOR team: B. Pritychenko (BNL), S. Hlavac, O. Gritzay, O. Schwerer (contractors), V. Zerkin (collaborator).
Missing Data in EXFOR

Not all experiments were compiled to SCISRS (Sigma Center Information Retrieval System, EXFOR precursor) database at Brookhaven in 1950s for historical (scope defined by applications) & technological (data were requested from authors or taken from published tables) reasons.

EXFOR project started to compile neutron cross sections and spontaneous fission since 1970, no FY until 1976.

Many important data sets were missed; comparison between EXFOR & Nuclear Science References (NSR) databases indicates that EXFOR could have 40,000+ experiments instead of 23,000.

Present day cost of a single experiment, LBL 88” Cyclotron example:

- $2,500 /hour beam time => $420 K/week
- Cost of $^{36}$S and $^{48}$Ca for ECR source are $47$ K/gram and $250$ K/gram, respectively
- Total price tag, conservatively, is $1$ M

It is cost effective to recover previous results than run new.
NNDC is responsible for experimental nuclear reaction data in the Area #1.

Nuclear structure-like search for FY NSR references was conducted at NNDC, Fall 2017:
- Potentially Missing Neutron FY: 384
- Potentially Missing Spontaneous FY: 142
- Potentially Missing Photo FY: 126

Results were initially reported:
- Informal NNDC-Los Alamos meeting, April 2018
- Workshop on Fission Product Yield Experimental Data, Los Alamos, August 20-23, 2018
- NRDC workshop, Vienna, October 22-25, 2018
- NRDC memos: CP-C 464, 465, 466, 469 (November 2018 – April 2019)

We analyzed the data, identified missing entries and collected PDFs (Not a trivial task but essential for compilations). \textbf{It took us 1 year to complete.}

The IAEA group started checking Mills, England & Rider for missing references in the Fall of 2018.


Workshop on Fission Product Yield Experimental Data, Santa Fe, September 30 - October 3, 2019: NNDC & IAEA efforts.
Status of FPY Compilations

• Since 12/19/2019 the IAEA runs Updating Fission Yields Data for Applications CRP: https://www.iaea.org/projects/crp/f42007

• The CRP specific objective: Compile all available experimental data on independent and cumulative fission yields, measured total kinetic energies and total neutron yields, mass and charge-yield data.

• NRDC runs FY compilations worldwide in support of the CRP.

• NNDC finished four NRDC memos compilations by March 31, 2021.

• NNDC proactively finds and compiles other fission data.
NNDC Charged Particle FY Compilations

- Charged particles (p, d, t, \(^{3,4}\)He, ...) were extensively used to study FY at Berkeley, Los Alamos, Argonne, University of Washington, ...

- Many fissioning systems could be produced in charged particle reactions (Bohr-Independence Hypothesis):
  - \(^{232}\)Th + \(^{4}\)He \(\rightarrow\) \(^{236}\)U
  - \(^{238}\)U + \(^{4}\)He \(\rightarrow\) \(^{242}\)Pu

- NSR contents were analyzed for charged particle fission reactions.

- NNDC raw compilation in FY2020 using NSR charged particle contents: 114 new and 7 updated.

- Compiled all works of J. Wilhelmy (LANL) and G. Seaborg (LBNL) into EXFOR.
Manhattan Project Data

• Fission yields and cross sections were produced by the Manhattan Project.
• Los Alamos National Laboratory library.
  • ~500 Los Alamos National Laboratory Reports were compiled into NSR database using the Primo library.
  • Nuclear reaction data reports from Los Alamos, Metallurgical and Pupin laboratories have been identified.
• Compilations of these data will start in December 2021.
Takeaways

• EXFOR FY compilation effort is complex and well-organized.
• Missing FY articles have been identified using NSR database (NNDC), R. Mills thesis and England & Rider (IAEA).
• NNDC (Area #1) finished four NRDC memos compilations and charged-particle FY by March 31, 2021.
• Further work will include extensive fission data search of the Manhattan Project laboratory reports to achieve completeness.