



**IAEA**

International Atomic Energy Agency  
*Atoms for Peace and Development*

# TM on Nuclear Data Retrieval, Dissemination, and Data Portals

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# Purpose of the meeting

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“TM on Nuclear Data Retrieval, Dissemination, and Data Portals” aims to:

- Evaluate existing tools and their capabilities:

- Web-API's,
- other retrieval methods
- GUI's
- Format conversion tools
- Etc.

from IAEA and participants,

- Review some use-cases,
- Discuss challenges in data format conversion and nuclear data pipelines
- Discuss best practises which would be necessary to establish an efficient Nuclear Data Portal

# Questions to be addressed

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Do we understand how different types of users (e.g. researchers, students, evaluators) want to use nuclear data for their purposes?

Would the nuclear data community be willing to contribute to data collection or submission efforts?

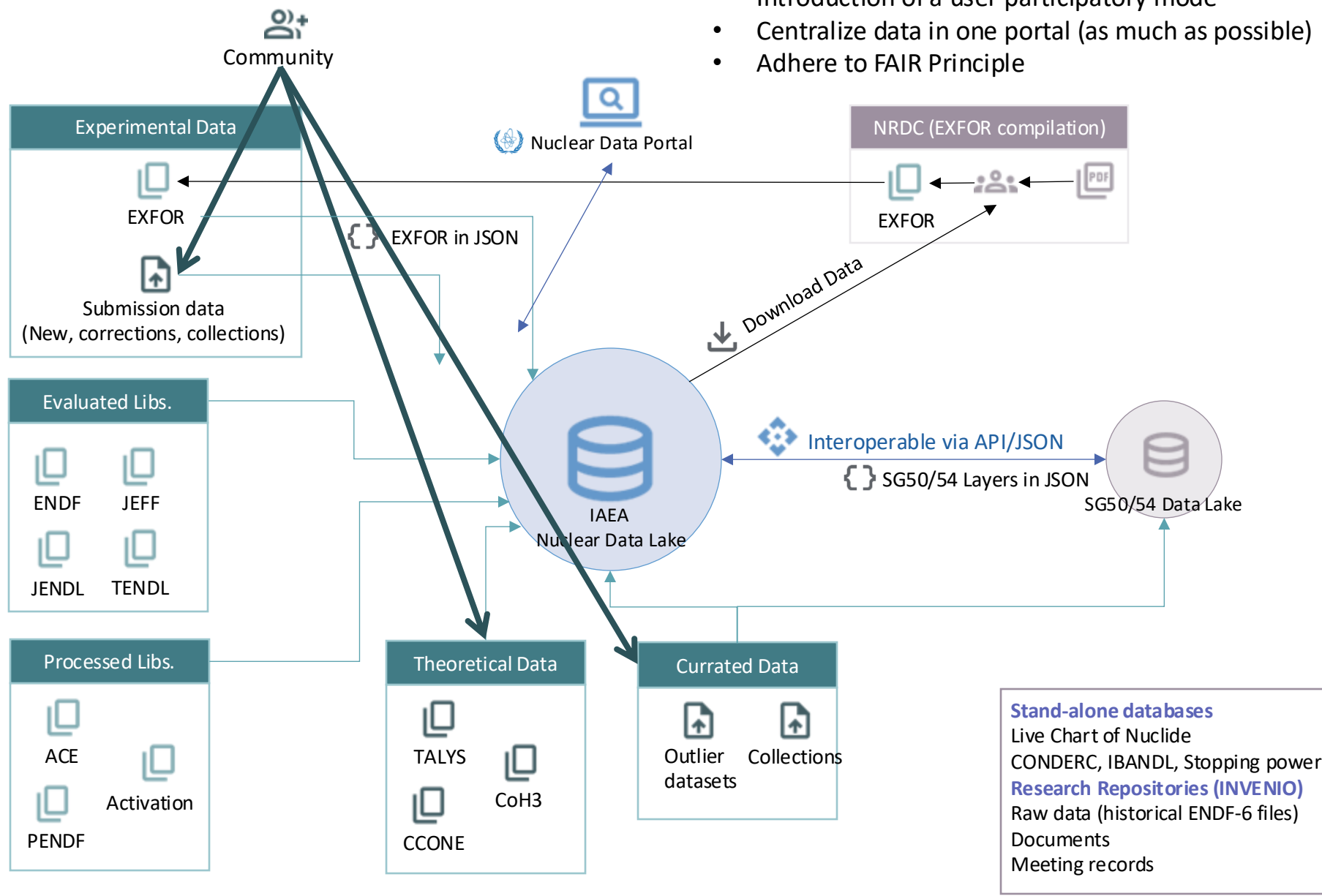
Will it result in a rapid distribution and sharing of data?



Can (almost) all nuclear reaction data be standardized to eventually develop a Data Portal similar to those in other fields of data science?

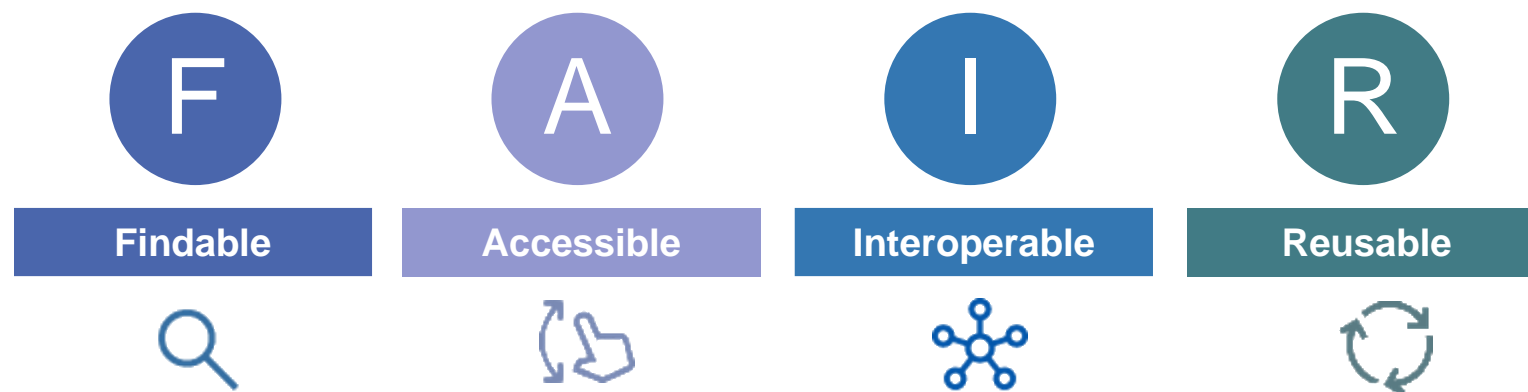
# Goal: Centralize nuclear reaction data into “Nuclear Data Portal”

- Introduction of a user participatory mode
- Centralize data in one portal (as much as possible)
- Adhere to FAIR Principle



# Why Adopt FAIR Principles?

- The IAEA Nuclear Data Section aims to make nuclear data coming from research (experimental, evaluated and theoretical) transparent and more robust by enabling users to re-use the data, following the idea of FAIR Principles.



- Adhering to the FAIR Data Principles helps ensure nuclear data:
  - Supports next-generation research in this field
  - Works well with machine learning (ML) and artificial intelligence (AI) models
  - Remains orderly and accessible at all levels of users
  - Supports data mining on prior works, saving time and resources

# What should be in Nuclear Data Lake/Data Portal?



## Existing nuclear data

- Historical evaluated nuclear data libraries
  - Metadata and data tables converted from ENDF-6 format
- Experimental nuclear reaction data
  - Metadata and data tables converted from EXFOR entries
- Other evaluated data:
  - EGAF, RIPL-3, IBANDL, thermal neutron observables, resonance parameters, etc.



## New data collections

- Theoretical Nuclear Reaction Data
  - Numerical data from theoretical studies related to scientific publications
  - Preliminary evaluation
- Users' collections
  - Users' suggestion of the correction/normalization onto experimental data
  - Users' collection
  - Users' new submission of preliminary data

- First target
  - Storing all physical quantities from the beginning is challenging
  - Start e.g. with cross-sections and fission yields

# Topics covered in the meeting (tentative)

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- Nuclear Data Flow/Pipeline
  - Evaluated nuclear data library data flow (e.g. ENDF-B and JEFF)
  - EXFOR data compilation workflow (OECD/NEA modernization efforts)
  - Inter-exchangeable and interoperable APIs
  - Interpretations (e.g. relating EXFOR reaction codes and ENDF MT/MF to nuclear physics)
- Technologies used in the portal/API developments
  - [NNDC](#) Portal from BNL
  - [JANIS](#) from OECD/NEA
  - [Live Chart of Nuclide](#) from IAEA/NDS
  - [Dataexplorer](#) from IAEA/NDS
- Data model
  - Universal metadata
    - Tabulated, self-explanatory, ready-to-use data
  - Re-design of existing nuclear data formats
    - Generalized Nuclear Data Structure ([GNDS](#))
    - Evaluated Nuclear Structure Data File (ENSDF) in JSON
    - Conversion of experimental nuclear reaction data (EXFOR) into JSON
  - New demands
    - Muon nuclear data (RIKEN initiative, M. Niikura et al., [arXiv:2403.19965](#))
    - Event generator cooperates in transport codes (e.g. CGMF in MCNP)
  - Robust data model for nuclear data (primarily nuclear reaction data)
- Study from Other Fields
  - [Atomic and molecular data and databases](#) from IAEA/NDS
  - High energy physics ([HEPdata](#))

# Nuclear reaction data in different shapes

### EXFOR

13-AL-27(N,TOT),,SIG  
 40-ZR-90(N,INL)40-ZR-90,PAR,SIG  
 26-FE-56(A,X)1-H-1,,DA/DE  
 3-LI-6(HE3,P)4-BE-8,PAR,DA  
 92-U-238(N,F),PR,NU/DE  
 92-U-235(N,F)0-G-0,PR,FY/DE  
 92-U-235(N,F)42-MO-99,CUM,FY  
 92-U-233(N,F),,AKE,LF+HF  
 94-PU-239(N,F),PR,NU

### ENDF-6

MF 3 MT 1  
 MF 3 MT 51-89  
 MF 4 MT 601  
 MF 6 MT none  
 MF 5 MT 18  
 MF 15 MT 18 x MF 12 MT 18  
 MF 8 MT 459  
 MF none MT none  
 MF 1 MT 456

Parsers have been developed,  
 Interpreters are still required.

### Nuclear Reaction Physics (experiments and theories)

Cross sections

- Cumulative: total, elastic, non-elastic
- Exclusive: (n,n'), (n,2n), (n,g), (n,f), (n,p),....
- Discrete level: (n,n'\_1), (n,n'\_2),....(n,p\_0),....
- Particle production: (n,xn), (n,xp),....
- Residual production: (n,x), (p,x),....

Angular distributions

- Elastic
- Inelastic

Single-differential emission spectra (energy)  
 Double-differential emission spectra (energy-angle)  
 Gamma-ray production cross sections  
 Fission yields  
 Fission neutron observables (average number of neutrons per fission, kinetic energy, etc.)

EXFOR Parser  
 +  
 Interpreters

EXFOR compilation  
 (Manual works)

ENDF Parser  
 +  
 Interpreters

Evaluation into ENDF-6 format  
 (Manual works)



# Expected functions of Nuclear Data Portal (to be discussed)

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- Backend
  - Pre-processing / online-processing of data
  - Handling of GNDS
  - ENDF-6 formatted data in JSON or tabulated format
  - EXFOR entries in JSON or tabulated format
  - Data flow and data storage
- Easy access to the data
  - Data model
  - (Meta)data are indexed in a searchable resource (nonSQL or SQL)
  - Enables the discovery and reuse of historical nuclear data by humans and machines
  - DOI or similar persistent URL assignment (preferably..)
  - Online plotting interface
  - Data download options with well described metadata
  - Interoperable (data retrievable) APIs between nuclear data centers
  - REST APIs endpoints for users
- User submission
  - User management in web applications (auth by IAEA NUCLEUS?)
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- etc..

# Expected outcomes (to be discussed)

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- Priorities
    - Focussing on nuclear reaction cross sections first, then?
  - Collection of use cases
    - Requests from users to developers
    - Existing AI/ML applications
    - New data idea and proposals
  - Collection of useful tools
    - Data processing, reformatting, plotting, visualizing, and storing
  - Recommendations
    - Ideas for the data model blueprint
      - Idea of creating a representation of the data structures, relationships, contains
    - Ideas for user participatory model
    - Ideas for data interpretations (e.g. relating EXFOR reaction codes and ENDF MT/MF to nuclear physics)
    - Conceptual data models
- :
- etc..

## TM on Nuclear Data Retrieval, Dissemination, and Data Portals - towards a blueprint of IAEA Nuclear Data Portal –

on **11-15 November 2024** at the IAEA Headquarter, Vienna, Austria

IAEA NDS will facilitate and support to accelerate the evolution of nuclear physics and nuclear data science. Input from member states matters.



*60 years and looking ahead to the next 10 years  
IAEA Nuclear Data Section*

Thank you for your  
cooperation!



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