

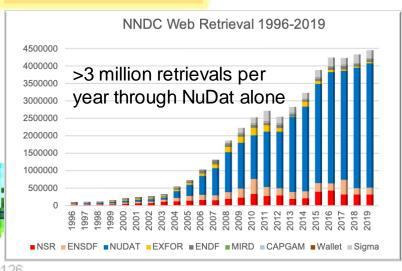
# Unique: Only database of its kind in the world

, number of protons

#### Authoritative:

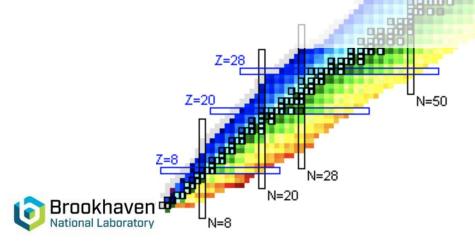
3,334 nuclides ~20,000 Reactions ~4,200 Decay

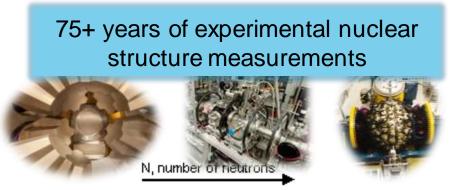
#### Highly used:



# ENSDF

# Evaluated Nuclear Structure Data File





# **ENSDF**: the ONLY comprehensive resource for

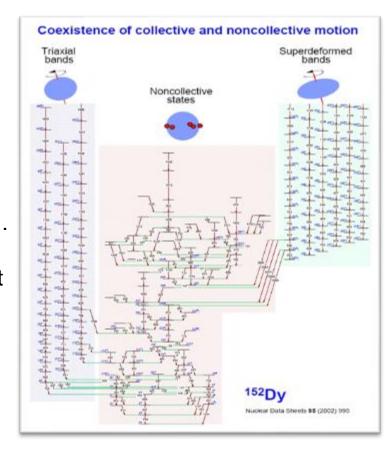
### **Nuclear Structure**

#### **Discrete Quantized States**

- Excitation Energy
- Half-life
- Angular Momentum
- Magnetic Moment
- Configuration
- •

#### **Emitted Radiation**

- Energy
- Intensity
- Dipole, Quadrupole, ...
- Mixing ratio
- Conversion coefficient

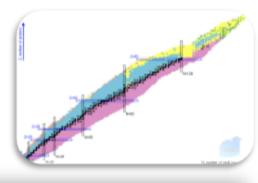


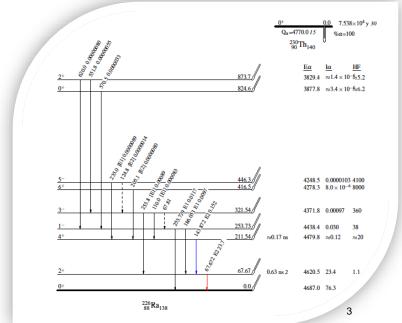
### **Nuclear Decay Data**

#### For each decay type:

- Half-life
- Branching ratio
- Energy
- Intensity
- Coincidences

. . .

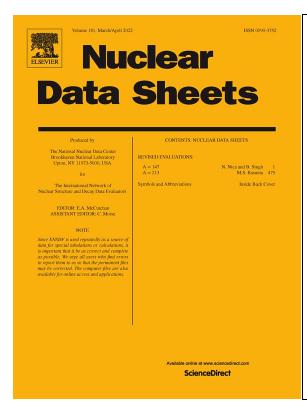






### The two faces of ENSDF

#### Pretty and readable





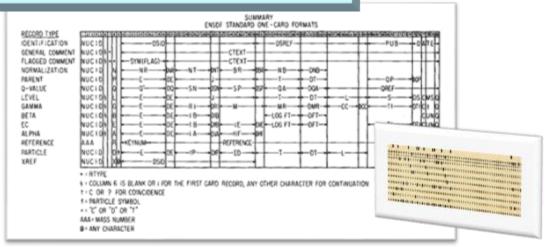
#### Less pretty...

```
225AC ADOPTED LEVELS, GAMMAS
                                                                09NDS
                                                                        200905
225AC H TYP=FUL$AUT=BALRAJ SINGH$CIT=ENSDF$CUT=25-0CT-2019$
225AC H TYP=UPD$AUT=B. Singh.J. Tuli$CUT=23-Feb-15$CIT=ENSDF$
225AC2 H COM=updated T1/2(GS)$
225AC H TYP=ERR$AUT=B. Singh$DAT=11-MAR-2013$COM=Some RI set to 100$
225AC H TYP=FUL$AUT=A. K. Jain (a), R. Raut (b), J. K. Tuli$
225AC2 H CIT=NDS 110, 1409 (2009)$CUT=1-Dec-2008$
225AC 0 -673 7 6668 6 4478 5 5935.1 14 2017WA10
225AC cQ $S(2n)=12331 {I8}, S(2p)=11323 {I5} (2017Wa10)
225AC c 1947En03, 1947Ha02: {+225}Ac identified from decay product of
225AC2c {+233}U series.
225AC c 1950Ha52: chemical separation of {+225}Ac.
225AC c 1972Ku26: fission isomer not observed in {+226}Ra(d,3n),E=11.3 MeV
225AC c 1988Le13: level energies were calculated for a deformed shell model
225AC2c (including octupole deformation) coupled to a reflection-asymmetric
225AC3c rotor core. The quadrupole deformation of [b{-2}=0.144 was used in
225AC4c calculations, and an octupole deformation of [b{-3}]?0.1
225AC5c was suggested.
225AC c Theoretical studies: consult the NSR database at www.nndc.bnl.gov for
225AC2c 14 references dealing with theoretical calculations for structure
225AC3c (levels, J|p, transition probabilities, etc.), and 62 for radioactive
225AC3c decay modes, in particular about {+14}C cluster emission.
225AC d Theoretical study on cluster radioactivity:
225AC2d 2008Bh05, 2005Bh02, 2005Ku04, 2005Ku32, 2004Ad41, 2004Ba64
225AC3d 2002Ba80, 2002Du16, 2002Sa55, 2002Ya04, 1999Mi09, 1998Mi30,
225AC4d 1997Ka11, 1995Si05, 1994Bu07, 1993Gu11, 1993Ka21, 1993Si26,
225AC5d 1990Bul3, 1989Ci03, 1988Sh29, 1987Sh04, 1987Po08, 1986Po15, 1985Po12.
225AC cG E,RI,M,MR$From {+229}Pa |a decay, unless otherwise stated.
225AC2cG Only the 40.09-keV transition is seen in {+225}Ra |b{+-} decay
225AC cG CC(y)$For |d=0.5 {I5} in analogy with the mixing ratio for 120.80|g
225AC cL E$From {+229}Pa |a decay
225AC cL J$From probable band assignments, in addition to some other arguments
225AC CL BAND(A)$|p3/2[532] band.
225AC CL BAND(B)$|p3/2[651] band.
225AC CL BAND(C)$[p5/2[523] band.
225AC CL BAND(D)$|p5/2[642] band.
225AC XA225RA B- DECAY (14.9 D)
225AC XB229PA A DECAY (1.50 D)
225AC PN
225AC L 0.0
                     (3/2-)
                                      9.920 D 3
225ACX L XREF=AB
225AC2 L %A=100 $ %14C=5.3E-10 13 (2001Gu33.1993Bo26)
```



# **Problem: Archaic format**

80 Column ASCII format



- All of nuclear physics doesn't fit in 80 columns
- No room to grow
- ML next to impossible
- Hard to engage next gen

```
137CS PN
137CS L 0.0
                    7/2+
                                      30.08 Y 9
137CSX L XREF=ACDEFGH
137CS2 L %B-=100$MOMM1=+2.8413 1 (1989Ra17)$MOME2=+0.051 1 (1989Ra17)
137CS cL T$Deduced by evaluators using the Limitation of Relative Statistical
137CS2cL Weights (LRSW) method for analyzing the following set of
137CS3cL discrepant (|h{+2}/|n=18.6) experimental values: 10970 d {I20}
137CS4cL (2004Sc04); 11018 d {II0} (2002Un02); 10941 d {I7} (1992Go24);
137CS5cL 10968 d {I5} (1990Ma15); 11009 d {I11} (1980Ho17); 10906 d {I33}
137CS6cL (1978Gr08); 11034 d {I29} (1973Co39); 11021 d {I5} (1973Di01); 11023 d
137CS7cL {I37} (1972Em01); 10921 d {I17} (1970Wa19); 11191 d {I157} (1970Ha32);
137CS8cL 11286 d {I256}, 10921 d {I183} (1965F101); 11220 d {I47} (1965Le25);
137CS9cL 10665 d {I110} (1963Ri02); 10840 d {I18} (1963Go03); 10994 d {I256}
137CSAcL (1962F109); 11103 d {I146} (1961Fa03);
137CSXCL 9715 d {1146} (1955Wi21). [1 y =365.242] A LOT of data stored in comments
137CS cL
                  Other evaluated results: 30.0
```

137CS2cL 30.08 y {I3} (1996ChZY, 1994Ka08); 30.1

**Evaluated Nuclear Structure** Data File

> A Manual for Preparation of Data Sets

> > Jagdish K. Tuli

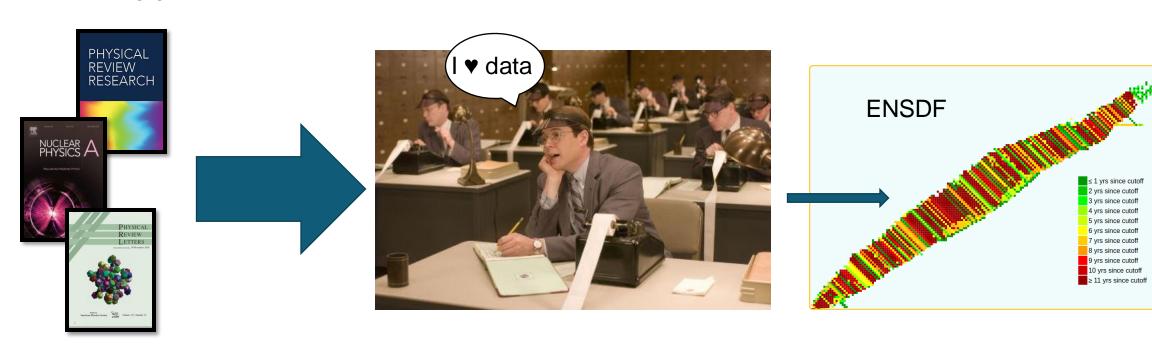
February, 2001



Non-standardized entry

## Low throughput

Torrents of nuclear data are being generated...



...but only a trickle is making it through.



## New object-oriented database

Migration from 80-column to JSON

```
"spinParityValues": [
       "spin": 2,
        "isTentativeSpin":
        "isTentativeParity":
        "parity": "+",
        "parityNumber"::
        "spin": 3,
        "isTentativeSpin":
        "isTentativeParity":
        "parity": "-"
        "parityNumber":
"comments":
```

# Validation: JSON Schema Official: https://json-schema.org/

- Defines schema & rules for a JSON document
- Can be used to validate data
- Can generate code from JSONSchema and vice-versa

```
• Powerful conditional rules
```

```
@ c.g. server-side

{
    "name": "Mary",
    "age": 25
}

Incoming data

(the "document")

### Comparison of the image of the im
```

Validation code



## Modular design

JSON schema can be composed from other component schema.

#### Benefits:

- Components can be reused, minimizing design effort.
- Changes to a component automatically propagate throughout the database.

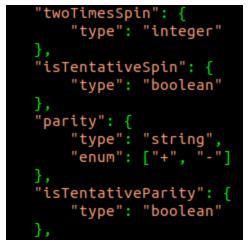
#### level.json

```
"spinParity": {
    "$ref": "spin-parity.json"
},
"levelEnergy": {
    "$ref": "level-energy.json"
},

"decayModes": {
    "type": "array",
    "minItems": 1,
    "items": {
        "$ref": "decay-mode.json"
    }
},
"halfLife": {
        "$ref": "halflife.json"
},
```

#### decay-mode.json

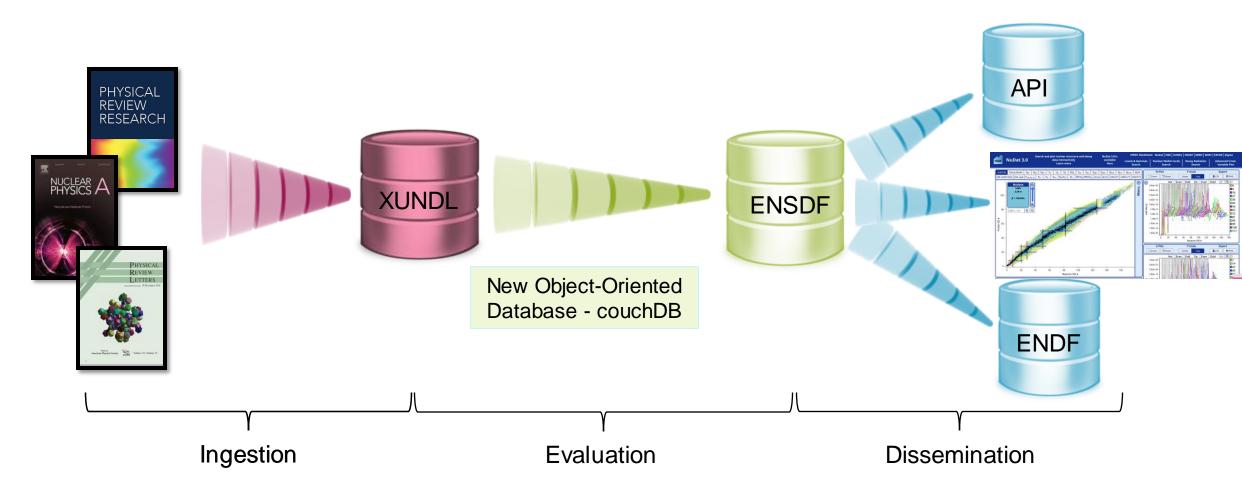
```
radiation":
   "type": "string",
   "enum":
       "proton"
        'neutron"
       "deuteron"
       "triton",
       "helion",
       "alpha",
       "betaMinus",
       "betaPlus",
       "electronCapture",
       "electronCaptureOrBetaPlus"
       "spontaneousFission",
       "cluster",
       "internalTransition"
```



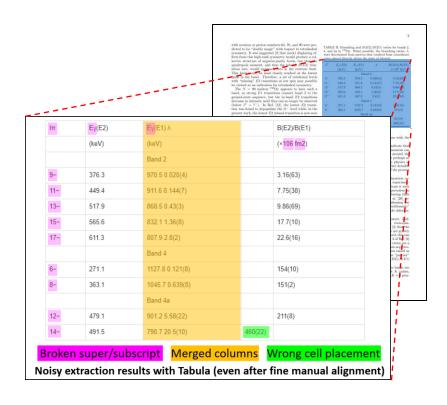
spin-parity.json

# **ENSDF Modernization**

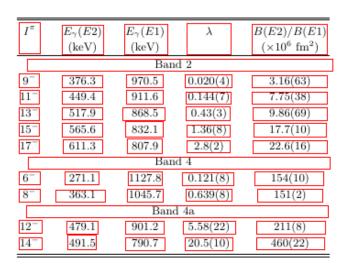
DOE has made significant investment to modernize and improve ENSDF 3 year project involving 3 DOE national laboratories — BNL – ANL - LLNL



# Ingestion: tabular recognition



Standard table extraction tools from PDFs (e.g. Tabula) require manual alignment and produce **very noisy results** 



New ML tool automatically identifies tables, detects structure, and extracts contents

Current performance: 93-97% table detection, 92% contents detection, 78-88% structure prediction, > 99% text extraction

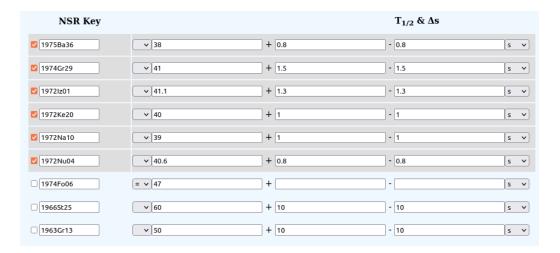
### **Evaluation**

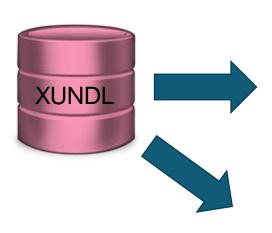
#### Present status:

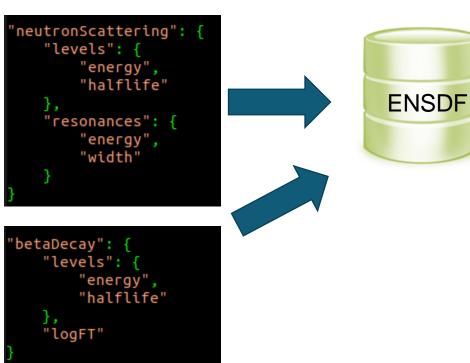
- XUNDL sources get "flattened" into ENSDF at every evaluation
- New evaluators essentially have to start from scratch

#### We envision:

- Unified format for XUNDL and ENSDF
- Automated process for merging (and preserving)
   XUNDL data into ENSDF
- Faster, less labor-intensive evaluations







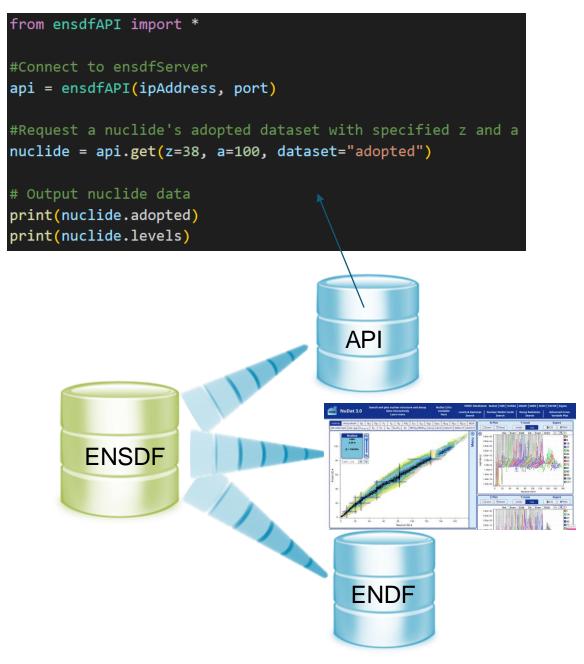
### **Dissemination**

#### Present status:

- We maintain our own web-based tools for data retrieval
- Downstream databases largely decoupled

#### We envision:

- Maintaining web tools
- More direct coupling between ENSDF and downstream products
- Providing an API for users with more bespoke needs



### **Dissemination**

#### Present status:

- We maintain our own web-based tools for data retrieval
- Downstream databases largely decoupled

#### We envision:

- Maintaining web tools
- More direct coupling between ENSDF and downstream products
- Providing an API for users with more bespoke needs

```
# Initialize API
api = ensdfAPI(ipAddress="127.0.0.1", port=5001)

# Get all ground state halflives
values_dict = api.filterByGroundStateHalfLife()

# Create dataframe and add log scale column
dataframe = plot.createViewDataFrame(values_dict)
dataframe["halflife_log"] = np.log2(dataframe["halfLife"])

# Label plot
plot.configuration.setAxisTitle("x", "log<sub>10</sub>(t<sub>1/2</sub> [s])")
plot.configuration.setAxisTitle("y", "Counts")

# Plot as a histogram
figure=plot.createHistogram(dataframe, "halflife_log")
plot.showFigure(figure)
```

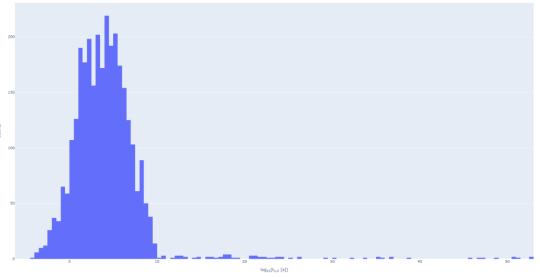


Image courtesy of Donnie Mason

### Where are we?

Started with a working but home-brewed schema validator for Adopted Levels, Gammas. Effectively unmaintainable.

```
Expanding <<<decays-observed-template.json>>> ------
Substituting %%%decay-mode-enum.json%% ------
Working on file transfer-dataset-template...
Validating files 1 -- 15... [DONE]
Validating files 16 -- 30...
```

Reworked validator into a maintainable and standardized structure, nearly all of the Adopted and (n,gamma) datasets are compliant.

```
Shu, Benjamin 8/5 9:11 AM

As of this morning:

3399/3409 Adopted datasets pass validation

574/602 N-Gamma datasets pass validation
```

Since then, have reached 100% validation of Adopted datasets, begun working on other reaction datasets with "gamma" in the DSID



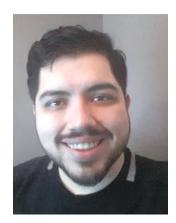
## The team



Elizabeth McCutchan



Ben Shu



Donnie Mason

Thanks for your attention!

