



ENSDF modernization

Chris Morse
For USNDP

Not Export Controlled



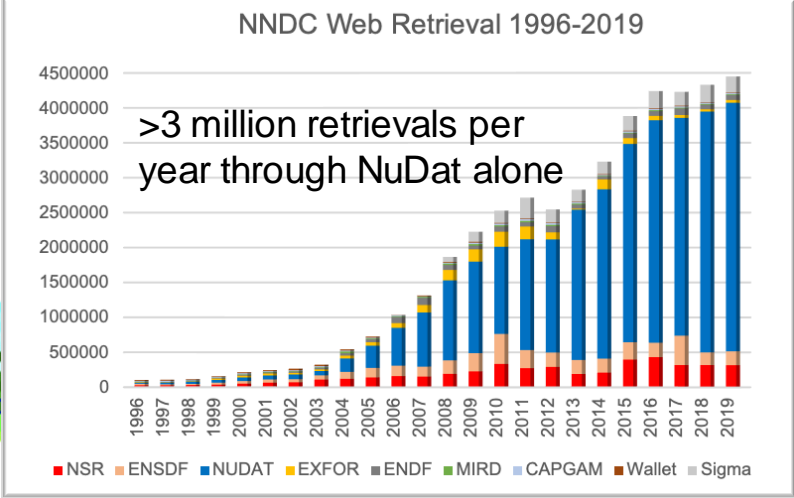
Unique :
Only database of its kind in the world

Highly used:

Z, number of protons

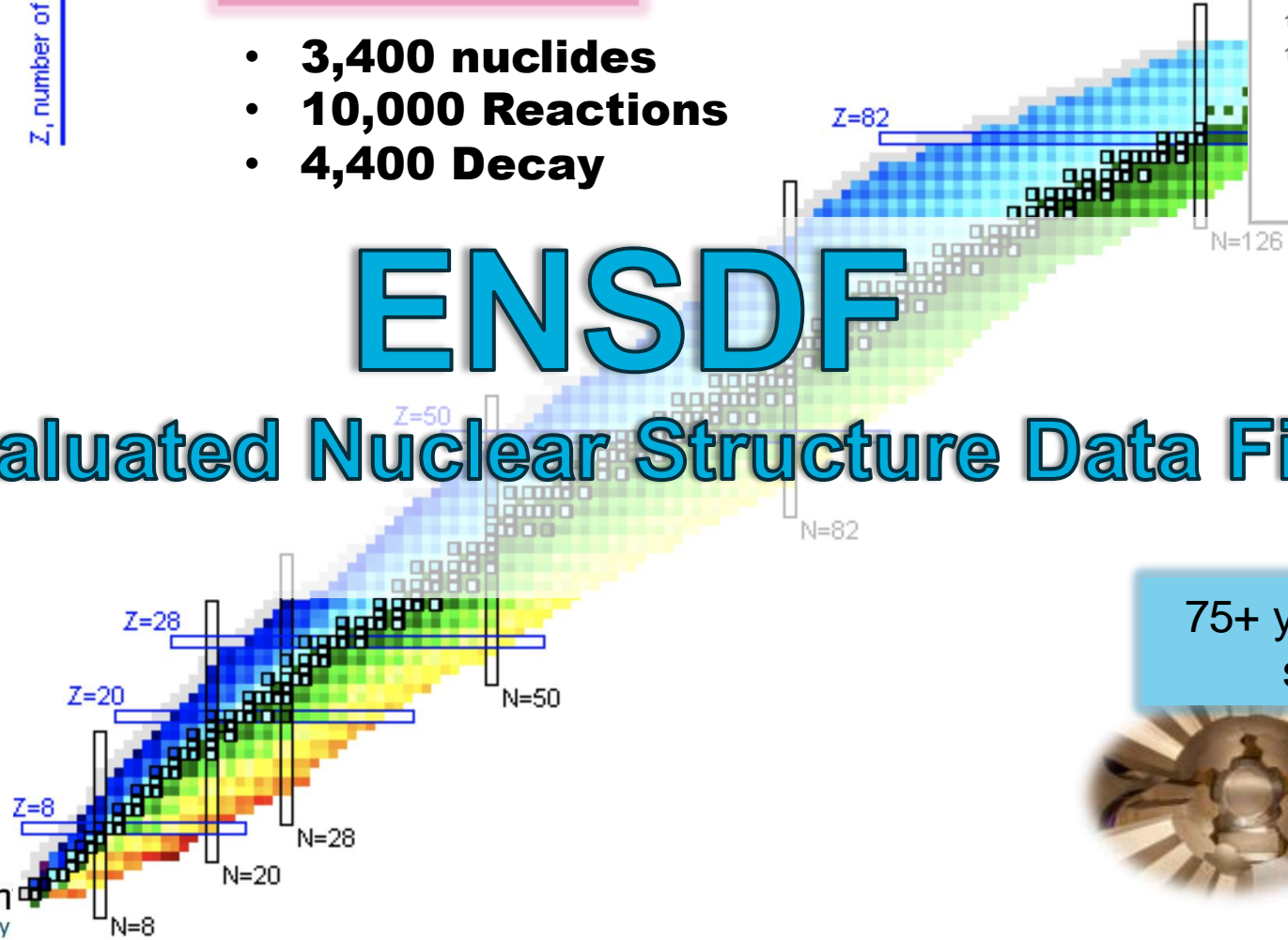
Authoritative:

- **3,400 nuclides**
- **10,000 Reactions**
- **4,400 Decay**



ENSDF

Evaluated Nuclear Structure Data File



75+ years of experimental nuclear structure measurements



N, number of neutrons

Problem: Archaic format

80 Column ASCII format

SUMMARY
ENSDF STANDARD ONE-CARD FORMATS

RECORD TYPE	NUC ID	DSID	DSREF	PUB	DATE
IDENTIFICATION	NUC ID				
GENERAL COMMENT	NUC ID		CTEXT		
FLAGGED COMMENT	NUC ID	SYNFLAG	CTEXT		
NORMALIZATION	NUC ID	NR	NT	BR	DB
PARENT	NUC ID	C	J	T	DT
Q-VALUE	NUC ID	Q	SN	SP	QA
LEVEL	NUC ID	E	J	T	DT
GAMMA	NUC ID	E	RI	RI	M
BETA	NUC ID	E	IB	IB	LE
EC	NUC ID	E	IB	IB	LE
ALPHA	NUC ID	E	IA	IA	RF
REFERENCE	AAA	KEYNUM	REFERENCE		
PARTICLE	NUC ID	OP	OT	L	
XREF	NUC ID	DSID			

*-RTYPE
!- COLUMN 6 IS BLANK OR I FOR THE FIRST CARD RECORD, ANY OTHER CHARACTER FOR CONTINUATION
!- C OR ? FOR COINCIDENCE
!- PARTICLE SYMBOL
!- "C" OR "O" OR "T"
AAA- MASS NUMBER
B- ANY CHARACTER

- 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 6
137CS L 0.0 7/2+ 30.08 Y 9 A
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 {I10} (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 {I146} (1955Wi21). [1 y =365.242
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

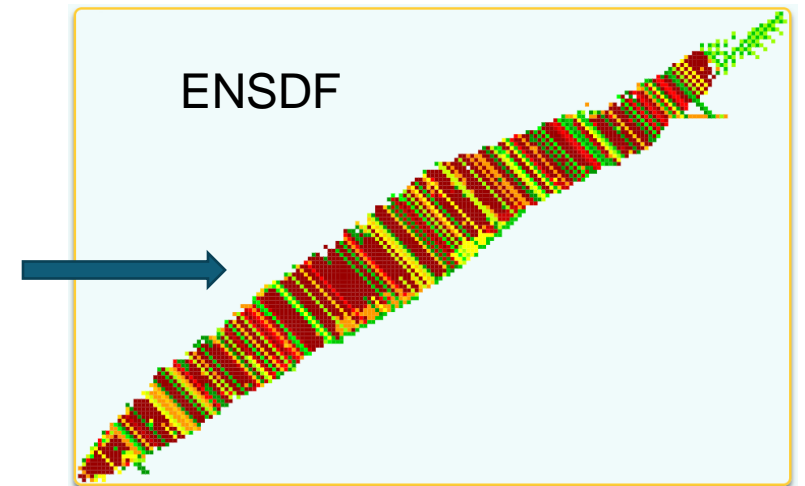
Jagdish K. Tuli

February, 2001

A LOT of data stored in comments
Non-standardized entry

Low throughput

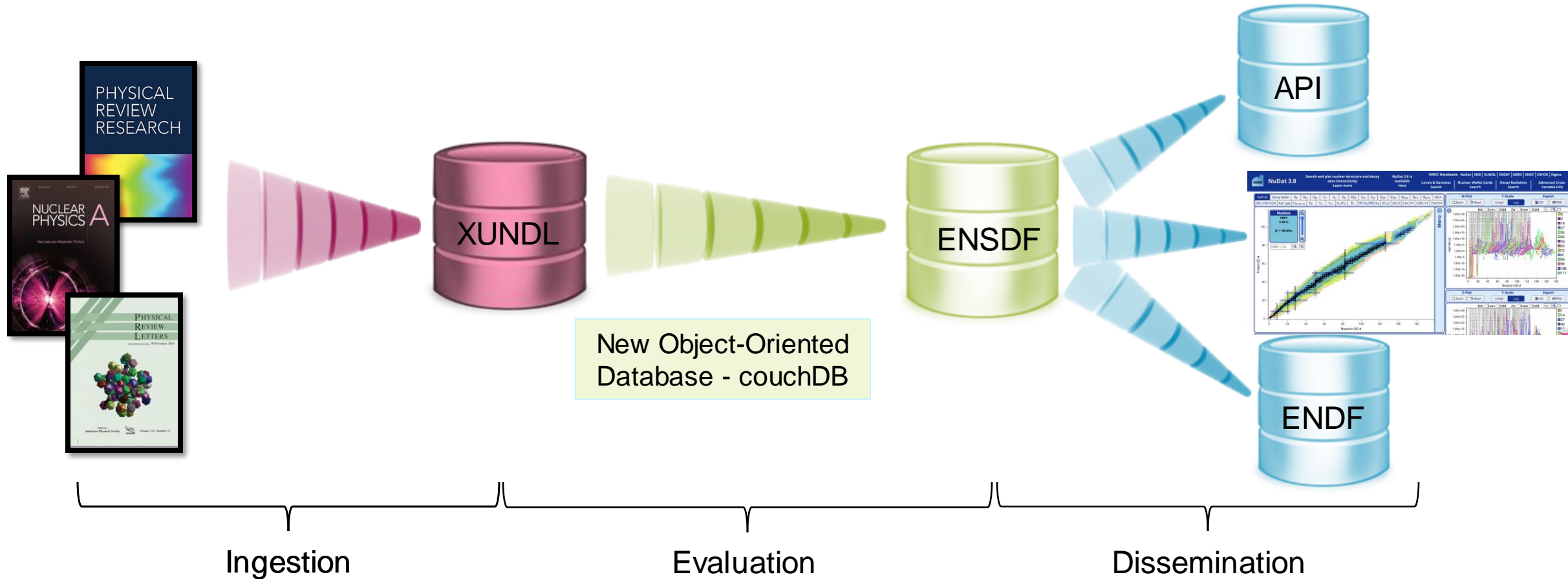
Torrents of nuclear data are being generated...



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

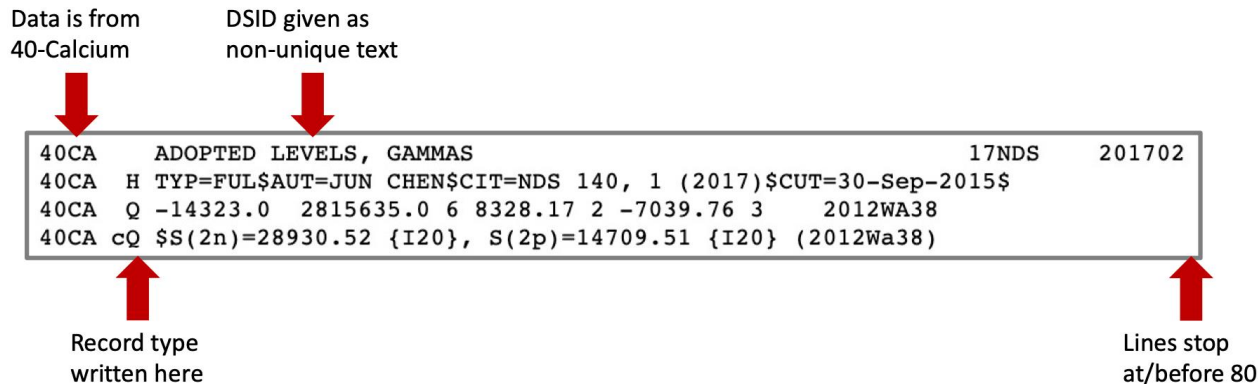
ENSDF Modernization

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



New object-oriented database

- Migration from 80-column to JSON, which has a simple set of rules
- Data are stored as key-value pairs
- Data types can be one of three things:
 - Simple: integer, boolean, string, etc
 - Object: a collection of key-value pairs
 - Array: an ordered sequence of values



```
"levels": [
  {
    "energy": {
      "unit": "keV",
      "value": 0,
      "uncertainty": {
        "type": "symmetric",
        "value": 0
      }
    },
    "halfLife": {
      "unit": "ms",
      "value": 19,
      "uncertainty": {
        "type": "asymmetric",
        "upperLimit": 17,
        "lowerLimit": 6
      }
    }
  }
]
```

Excerpt of real data from ^{291}Lv
Adopted Levels

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

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

Incoming data

(the "document")

*Validation code
e.g. server-side*

```
{  
  "properties": {  
    "name": {  
      "type": "string"  
    },  
    "age": {  
      "type": "integer",  
      "minimum": 0  
    }  
  }  
}
```

*JSON-Schema
definition*



Status

- All datasets have been converted to the new JSON format
- Based on their DSIDs, datasets have been sorted into the categories in the table
- All of them pass validation
- Total: 18,841

Dataset	Number	Dataset	Number
Adopted	3398	Isomer decay	583
Coulomb excitation	385	Spontaneous fission	248
Neutron capture	605	Prompt particle decay	48
General reaction	6939	Delayed particle decay	274
Transfer	2562	Fluorescence	195
Alpha decay	829	Charge exchange	140
Beta decay	2355	Comments*	280

*Comments are datasets with no numerical data, irrespective of DSID

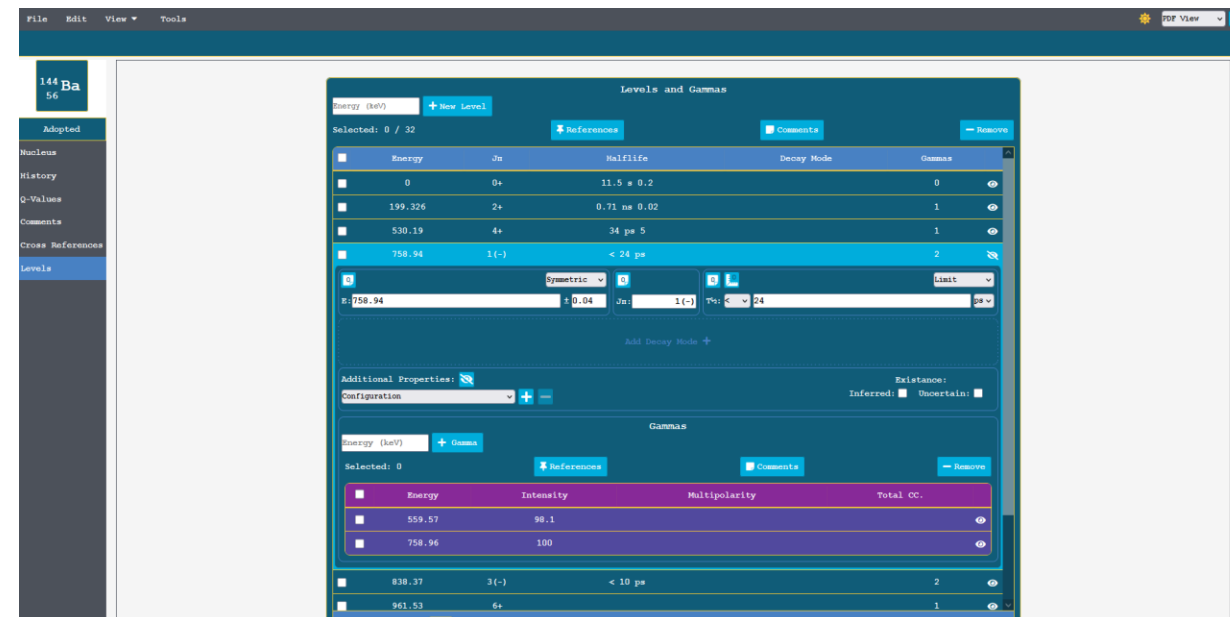
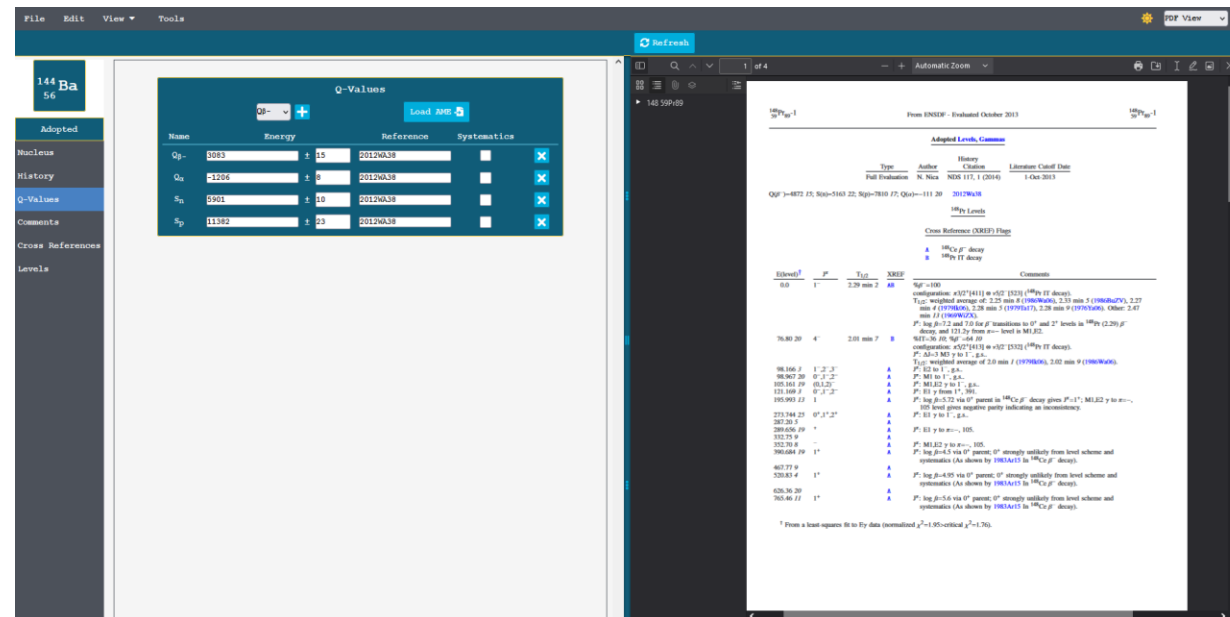
New or modified features

- Datasets can now be filtered based on their type, not just DSID
 - NB: We have to rely on DSID during conversion
- Dedicated list of evaluated measurements. Replaces freeform comments
 - NB: We cannot reliably fill this in during conversion
- Thousands of errors fixed and continuation records standardized

```
"measurements": {
  "evaluationMethod": "weightedAverage",
  "evaluationComment":
  "Weighted average of 20.5 s \textit{23} (2014An02) and 20.1 s
  \textit{15} (2016Yr11). Other: 20 s \textit{3} (2013AnYZ), superceded
  by 2014An02.",
  "measuredValues": [
    {
      "value": 20.5,
      "unit": "s",
      "uncertainty": {
        "type": "symmetric",
        "value": 2.3
      },
      "isIncluded": true,
      "reference": "2014An02"
    },
    {
      "value": 20.1,
      "unit": "s",
      "uncertainty": {
        "type": "symmetric",
        "value": 1.5
      },
      "isIncluded": true,
      "reference": "2016Yr11"
    },
    {
      "value": 20,
      "unit": "s",
      "uncertainty": {
        "type": "symmetric",
        "value": 3
      },
      "isIncluded": false,
      "reference": "2013AnYZ",
      "comment": "superceded by 2014An02"
    }
  ]
}
```

ENSDF file editor

- New editor developed for creating and modifying ENSDF files
- Expected to be how evaluators interface with the JSON
 - Editor can automatically handle indexing of levels and radiation
- Intent is to provide as many tools to automate the evaluation process as possible



A small demo

- About a year ago, a researcher emailed me to ask for all half-lives in ENSDF
- Fulfilling this simple request took several emails and multiple staff members writing parsing codes
- Turnaround time was two or three days
- Now it takes 30 lines of code

```
import os
import json
import ROOT
import numpy as np
directory = "/home/chris/ensdf/json/adopted"

ROOT.gStyle.SetOptStat(0)

#Want logarithmically sized bins
bins = np.array([1e-12, 1e-11, 1e-10, 1e-9, 1e-8, 1e-7, 1e-6, 1e-5, 1e-4, 1e-3, 1e-2,
                1e-1, 1, 1e1, 1e2, 1e3, 1e4, 1e5, 1e6, 1e7, 1e8, 1e9, 1e10, 1e11, 1e12])

h = ROOT.TH1F("hist", "HalfLife (s)", 24, bins)

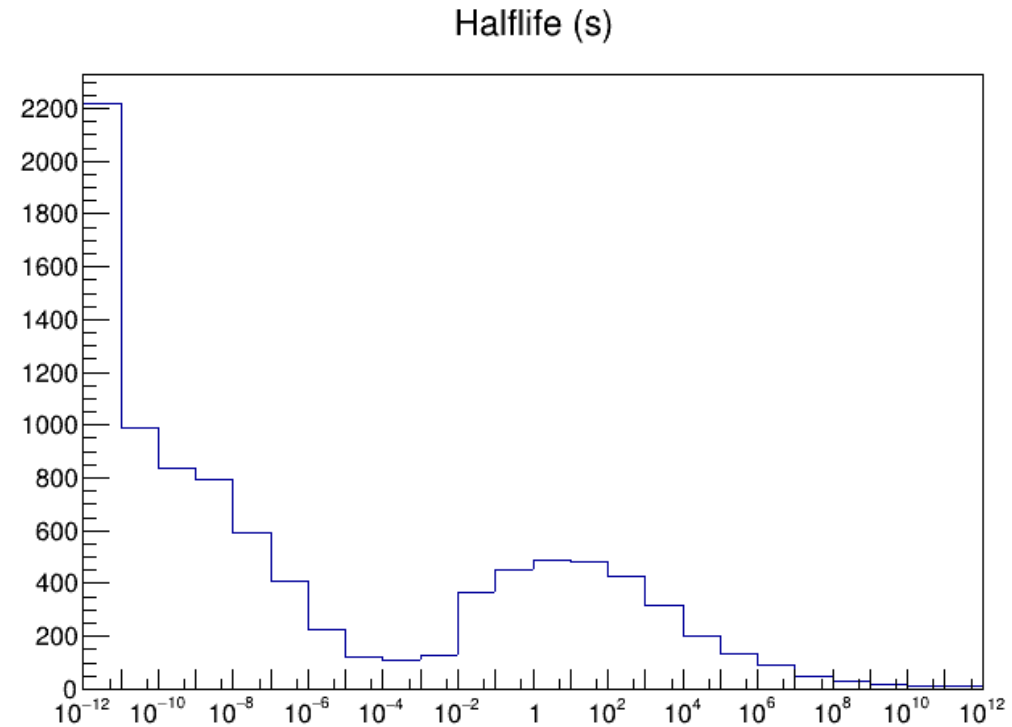
convertToSeconds = {"as": 1e-18, "fs": 1e-15, "ps": 1e-12, "ns": 1e-9, "us": 1e-6, "ms": 1e-3,
                   "s": 1., "m": 60., "h": 3600., "d": 3600*24., "y": 3600*24*365.25}

for filename in os.listdir(directory):
    with open(os.path.join(directory, filename), 'r') as jsonfile:
        jsondata = json.load(jsonfile)
        try:
            for level in jsondata["levels"]:
                try:
                    halfLife = level["halfLife"]
                    if halfLife["uncertainty"]["type"] != "limit":
                        h.Fill(halfLife["value"]
                              *convertToSeconds[halfLife["unit"]])
                except:
                    pass
        except:
            pass

h.Draw()
input("Press any key to continue...")
```

A small demo

- About a year ago, a researcher emailed me to ask for all half-lives in ENSDF
- Fulfilling this simple request took several emails and multiple staff members writing parsing codes
- Turnaround time was two or three days
- Now it takes 30 lines of code
- Can directly use ENSDF in ROOT applications (via PyROOT)



What's next?

- Release!
 - We expect to treat initial release as public beta
- Training for evaluators and users
- Update the software ecosystem which exists around the 80-column format
- XUNDL...

The team

- NNDC: Libby McCutchan, Donnie Mason, Andrea Mattera, Shuya Ota, Ben Shu, Jin Wu
- BNL Computer Science Initiative: C.X. Soto, T. Flynn

**Thanks for
your attention!**