



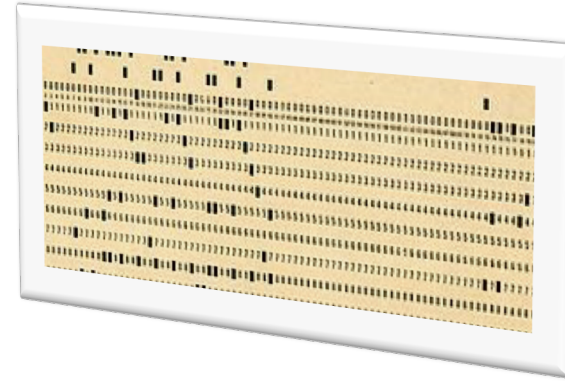
# Modernization of the Evaluated Nuclear Structure Data File (ENSDF)





# Current ENSDF format

## 80 Column ASCII format



80 column fields

SUMMARY  
ENSDF STANDARD ONE-CARD FORMATS

RECORD TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
IDENTIFICATION	NUC ID	DSID				DSREF										PUB															DATE																																																	
GENERAL COMMENT	NUC ID	§	CTEXT				CTEXT																																																																									
FLAGGED COMMENT	NUC ID	§	SYM(FLAG)																																																																													
NORMALIZATION	NUC ID	N	NR	NT	NT	BR	BR	NB	DNB																																																																							
PARENT	NUC ID	P	E	DE	J	T	DT	OP	OP																																																																							
Q-VALUE	NUC ID	Q	Q <sup>+</sup>	DQ	SN	DSN	SP	DSP	QA	DQA	QREF																																																																					
LEVEL	NUC ID	L	E	DE	J	T	DT	L	S	DS	MS	Q																																																																				
GAMMA	NUC ID	G	E	DE	R	I	DI	M	MR	DMR	CC	DCC	TI	DT	CT	Q																																																																
BETA	NUC ID	B	E	DE	I	B	DIB	LOG FT	DFT																																																																							
EC	NUC ID	E	E	DE	I	B	DIB	IE	DIE	LOG FT	DFT																																																																					
ALPHA	NUC ID	A	E	DE	I	A	DIA	HF	DHF																																																																							
REFERENCE	AAA	R	KEYNUM				REFERENCE																																																																									
PARTICLE	NUC ID	D	E	DE	I	P	DIP	ED	T	DT	L																																																																					
XREF	NUC ID	X	B	DSID																																																																												

\* = RTYPE  
§ = COLUMN 6 IS BLANK OR I FOR THE FIRST CARD RECORD, ANY OTHER CHARACTER FOR CONTINUATION  
† = C OR ? FOR COINCIDENCE  
f = PARTICLE SYMBOL  
+ = "C" OR "D" OR "T"  
AAA = MASS NUMBER  
@ = ANY CHARACTER

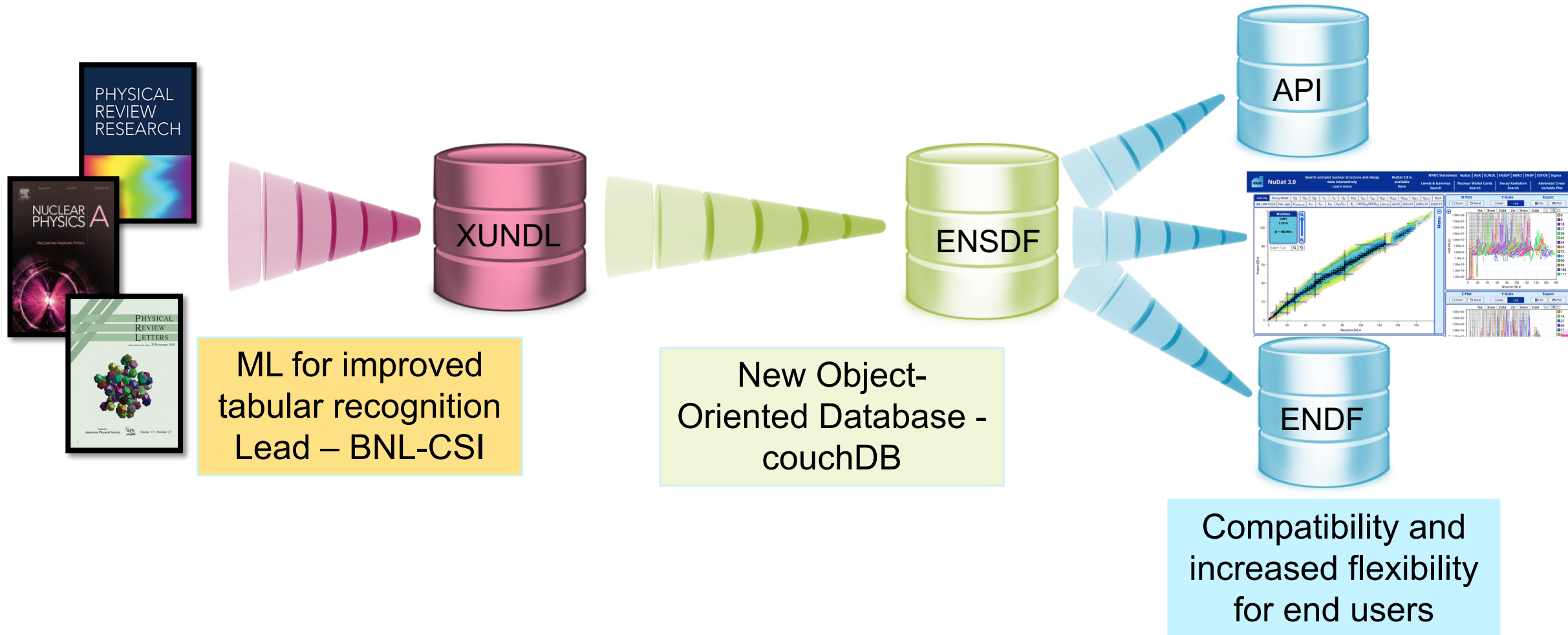
```
137CS PN  
137CS L 0.0      7/2+      30.08 Y   9  
137CSX L XREF=ACDEFGH  
137CS2 L %B-=100$MOMM1=+2.8413 1 (1989Ra17)$MOME2=+0.051 1 (1989Ra17)  
137CS cL T$Deduced by evaluators using the Limitation of Relative Statistical  
137CS2cL Weights (LRSW) method for analyzing the following set of  
137CS3cL discrepant (|h{+2}|/n=18.6) experimental values: 10970 d {I20}  
137CS4cL (2004Sc04); 11018 d {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); 1  
137CS8cL 11286 d {I256}, 10921 d {I183} (1965F101); 11
```

“Continuation record”

A LOT of data stored in comments  
Non-standardized entry

# ENSDF Modernization

DOE has made significant investment to modernize and improve ENSDF



# Ingestion: ML for tabular recognition

Will benefit communities beyond ENSDF !!

with neutron or proton numbers 64, 70, and 90 were predicted to be "doubly magic" with respect to tetrahedral symmetry. It was suggested [2] that nuclei displaying effects from this high-rank symmetry would produce a collective structure of negative-parity levels, by which the quadrupole moment, and thus the  $B(E2)/B(E1)$  transition rate, would **grow** in the extreme limit. This **prediction** is most closely reached at the lowest **spin** in the band. Therefore, a set of rotational levels with "missing"  $E2$  transitions at low spin may possibly be viewed as an indication for tetrahedral symmetry. The  $N = 90$  nucleus  $^{140}\text{Dy}$  appears to have such a band, as strong  $E1$  transitions connect band 2 to the ground-state sequence, but the in-band  $E2$  transitions decrease in intensity until they can no longer be observed (below  $J^\pi = 7^-$ ). In Ref. [12], the lowest  $E2$  transition was found to depopulate the 11- level while, in the present work, the lowest  $E2$  in-band transition is now seen

TABLE II: Branching and  $B(E2)/B(E1)$  ratios for bands 2, 4, and 4a in  $^{140}\text{Dy}$ . When possible, the branching ratios,  $\lambda$ , were determined from spectra that resulted from coincidence gates placed directly above the state of interest.

$J^\pi$	$E_\gamma(E2)$ (keV)	$E_\gamma(E1)$ (keV)	$\lambda$	$B(E2)/B(E1)$ ( $\times 10^6 \text{ fm}^2$ )
Band 2				
9 <sup>-</sup>	376.3	970.5	0.020(4)	3.16(63)
11 <sup>-</sup>	449.4	911.6	0.144(7)	7.75(38)
13 <sup>-</sup>	517.9	868.5	0.43(3)	9.86(69)
15 <sup>-</sup>	565.6	832.1	1.36(8)	17.7(10)
17 <sup>-</sup>	611.3	807.9	2.8(2)	22.6(16)
Band 4				
6 <sup>-</sup>	271.1	1127.8	0.121(8)	154(10)
8 <sup>-</sup>	363.1	1045.7	0.639(8)	151(2)
Band 4a				
12 <sup>-</sup>	479.1	901.2	5.58(22)	211(8)
14 <sup>-</sup>	491.5	790.7	20.5(10)	460(22)

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Broken super/subscript   Merged columns   Wrong cell placement  
 Noisy extraction results with Tabula (even after fine manual alignment)

GUI is being finalized.  
 Training will begin soon.

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

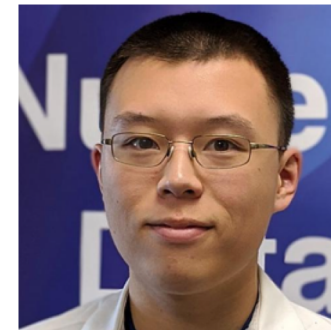
Current performance: 93-97% table detection, 92% contents detection, 88% structure prediction, > 99% text extraction

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

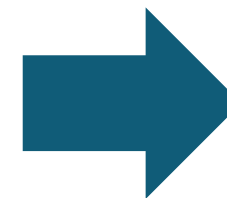
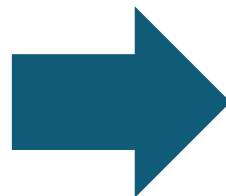
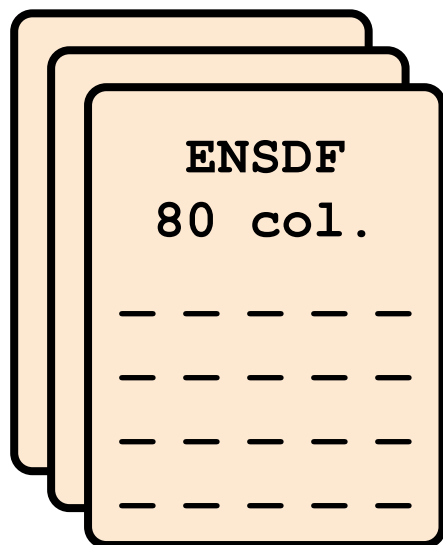


# Converting Existing ENSDF

Ben Shu



- Implemented through the **ensdftojson** project
  - Java library for modeling/printing ENSDF data
  - Converts all 3,392 Adopted Levels datasets in ~1 minute



```
2   "header": {
3     "schemaVersion": "1.0",
4     "documentType": "nuclide",
5     "z": 62,
6     "n": 90,
7     "a": 152,
8     "elementName": "Samarium",
9     "elementSymbol": "Sm",
10    "history": [{
11      "evaluationType": "full",
12      "cutoffDate": "2013-08-31",
13      "authors": [{
14        "name": "M. J. MARTIN"
15      }],
16      "publication": "NDS 114, 1497 (2013)"
17    }],
18  },
```

# JSONSchema

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



Chris Morse

```
{  
  "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



100's of errors in current ENSDF identified in batch validation



# Example of ENSDF errors

- 100's of instances where duplicate subshells were given
- JSON schema allows only one entry per subshell
- All from same time period, looks like previous Brlcc inputs not cleared

```
230TH CL J          463.6G M1+E2 to 1-, 399.95G M1+E2 to 3-.
230TH  G 294.23      2  0.65    9 E1                      0.0388
230THS G KC=0.0311 5$LC=0.00585 9$MC=0.001403 20$NC+=0.000475 7
230THS G NC=0.000371 6$OC=8.63E-5 12$PC=1.609E-5 23$QC=1.231E-6 18
230TH  G 399.95      2  7.8     5 M1+E2                1.4      6      0.18    9
230THS G KC=0.13 8$LC=0.036 9$MC=0.0089 20$NC+=0.0031 7
230THS G NC=0.0024 6$OC=0.00056 13$PC=0.00010 3$QC=7.E-6 4
230THS G NC AP 0.00316$OC AP 0.000745$PC AP 0.0001426$QC AP 1.243E-5
230TH  G 463.59      6 10.3    7 M1+E2                -0.28   3      0.242   5
230THS G KC=0.194 4$LC=0.0588 7$MC=0.00884 15$NC+=0.00303 5
230THS G NC=0.00236 4$OC=0.000557 10$PC=0.0001079 19$QC=1.008E-5 20
230THS G NC AP 0.00226$OC AP 0.000535$PC AP 0.0001033$QC AP 9.49E-6
```

# 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.

adopted-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"
  ]
}
```

```
"twoTimesSpin": {
  "type": "integer"
},
"isTentativeSpin": {
  "type": "boolean"
},
"parity": {
  "type": "string",
  "enum": ["+", "-"]
},
"isTentativeParity": {
  "type": "boolean"
},
}
```

spin-parity.json



# CouchDB for expanded data storage

- .CouchDB handles binary objects
- .Potential to speed the workflow
- .Example: preserve valuable history of evaluator's notes
- .Content for internal use
- .Any format → no editing needed**

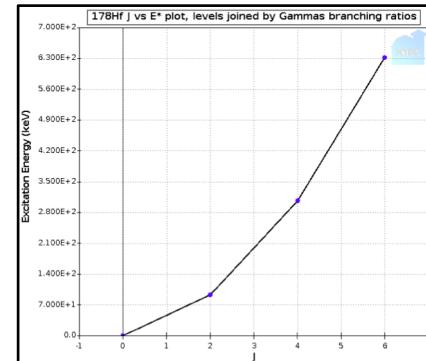
```
"_id": "72,178",  
"author": {},  
"reviewDate": "1/1/1980",  
"evaluatorNotes": {↔},  
"levels": {  
  "A": r
```

Icons: [thenounproject.com/indygo/](http://thenounproject.com/indygo/)

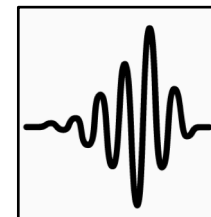
## Website links

See: [www.nndc...](http://www.nndc...)

## Screenshots



## Even audio



## Typed notes

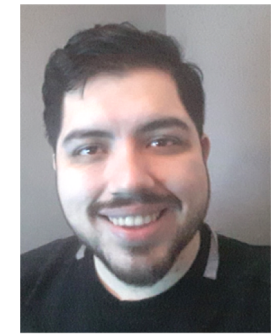
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

## Scanned handwritten

E(level) <sup>†</sup>	L <sup>‡</sup>	dσ/dΩ(25°) <sup>#</sup>
0.0	0	266
80 1		21
264 1		12
548 1		2.1
821 2		<del>3.7</del> 2.9
997 2		12
1195 2		≈4.5
1217 2	0	30
1275 2		2.7
1359 3		3.0
1411		5.4
1422	0	21

typo in orig.

# Beta version of Editor nearly ready



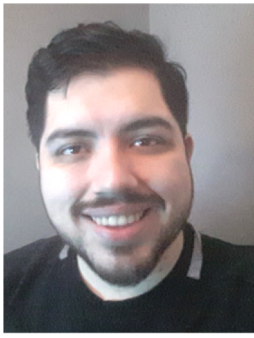
Donnie Mason

The screenshot displays the ENSDF Editor interface. On the left, a sidebar shows navigation options: Nucleus, History, Q-Values, Comments, Cross References, and Levels. The main area is split into two panes. The left pane contains a form for entering nuclear data for  $^{138}\text{Ba}$  (Z=56, N=82). The form fields are: Atomic Mass (A): 138, Element Symbol: Ba, Element Name: Barium, Protons (Z): 56, and Neutrons (N): 82. A 'Submit' button is at the bottom. The right pane shows a dual view of the ENSDF data and its corresponding JAVA-NDS pdf. The pdf is titled '138ba\_nds.pdf' and shows the adopted levels and gamma transitions for  $^{138}\text{Ba}$ . The pdf content includes a table of levels and transitions, and a list of references.

Level	J <sup>π</sup>	T <sub>1/2</sub>	XREF	Comments
0.0	1 <sup>+</sup>	2.29 min 2	AB	%β <sup>-</sup> =100 configuration: π3/2 <sup>+</sup> [411] @ π5/2 <sup>+</sup> [521] ( <sup>138</sup> Pu IT decay). T <sub>1/2</sub> : weighted average of: 2.28 min 8 (1980W06), 2.33 min 5 (1980BzV), 2.27 min 4 (1979H06), 2.28 min 5 (1979Ta17), 2.28 min 9 (1976Y06). Other: 2.47 min 1 (1969W02).
76.80 20	4 <sup>-</sup>	2.01 min 7	B	P <sup>+</sup> : log β=7.2 and 7.8 for β <sup>-</sup> transitions to 0 <sup>+</sup> and 2 <sup>+</sup> levels in <sup>140</sup> Pu (2.29) β <sup>-</sup> decay and 121.2y from π- level in M1E2. %IT=56.10, %β <sup>-</sup> =43.90 configuration: π3/2 <sup>+</sup> [413] @ π3/2 <sup>+</sup> [532] ( <sup>140</sup> Pu IT decay). P <sup>+</sup> : ΔI=3 MJ y to 1 <sup>+</sup> , g.s. T <sub>1/2</sub> : weighted average of: 2.0 min 1 (1979H06), 2.02 min 9 (1980W06).
98.166 3	1 <sup>+</sup> , 2 <sup>+</sup> , 3 <sup>+</sup>		A	P <sup>+</sup> : E2 to 1 <sup>+</sup> , g.s.
98.967 20	0 <sup>+</sup> , 1 <sup>+</sup> , 2 <sup>+</sup>		A	P <sup>+</sup> : M1 to 1 <sup>+</sup> , g.s.
102.161 19	(0.1, 2 <sup>+</sup> )		A	P <sup>+</sup> : M1E2 y to 1 <sup>+</sup> , g.s.
121.169 3	0 <sup>+</sup> , 1 <sup>+</sup> , 2 <sup>+</sup>		A	P <sup>+</sup> : E1 y from 1 <sup>+</sup> , 391.
195.993 13	1		A	P <sup>+</sup> : log β=5.72 via 0 <sup>+</sup> parent in <sup>140</sup> Ce β <sup>-</sup> decay gives J <sup>π</sup> =1 <sup>+</sup> ; M1E2 y to π-. 105 level gives negative parity indicating an inconsistency. P <sup>+</sup> : E1 y to 1 <sup>+</sup> , g.s.
273.744 25	0 <sup>+</sup> , 1 <sup>+</sup> , 2 <sup>+</sup>		A	
287.20 3			A	
289.656 19	+		A	P <sup>+</sup> : E1 y to π- = 105.
332.75 9			A	
352.70 8			A	P <sup>+</sup> : M1E2 y to π- = 105.
390.684 19	1 <sup>+</sup>		A	P <sup>+</sup> : log β=4.5 via 0 <sup>+</sup> parent; 0 <sup>+</sup> strongly unlikely from level scheme and systematics (As shown by 1983Ar15 in <sup>140</sup> Ce β <sup>-</sup> decay).
467.7 9			A	
520.83 4	1 <sup>+</sup>		A	P <sup>+</sup> : log β=4.95 via 0 <sup>+</sup> parent; 0 <sup>+</sup> strongly unlikely from level scheme and systematics (As shown by 1983Ar15 in <sup>140</sup> Ce β <sup>-</sup> decay).
626.36 20			A	
765.46 11	1 <sup>+</sup>		A	P <sup>+</sup> : log β=5.6 via 0 <sup>+</sup> parent; 0 <sup>+</sup> strongly unlikely from level scheme and systematics (As shown by 1983Ar15 in <sup>140</sup> Ce β <sup>-</sup> decay).

- Runs locally on your browser – no internet connection required
- Dual view (similar to latex) of both ENSDF data and JAVA-NDS pdf





# Beta version of Editor nearly ready

- You will be hearing from Donnie soon
- Scheduling small group demos to collect feedback and suggestions

Levels and Gammas

Selected: 0 / 32

Energy	J $\pi$	Halflife	Decay Mode	Gammas
0	0+	11.5 s 0.2		0
199.326	2+	0.71 ns 0.02		1
530.19	4+	34 ps 5		1
758.94	1-	< 24 ps		2
838.37	3-	< 10 ps		2

E: 838.37 ± 0.05 J $\pi$ : J $\pi$  T $\frac{1}{2}$ : < 10 PS Limit

Additional Properties: Configuration Existence: Inferred: Uncertain:

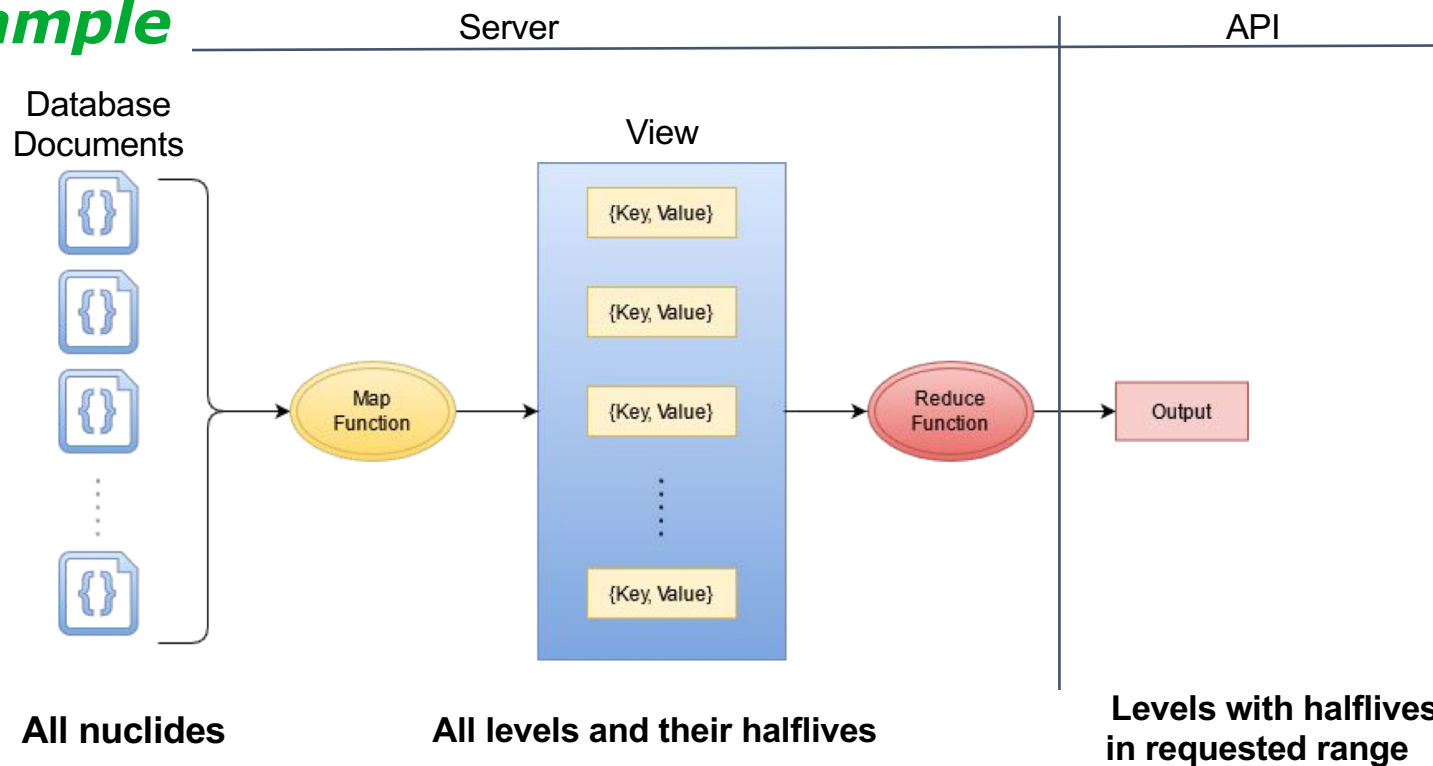
Gammas

Energy	Intensity	Multipolarity	Total CC.
308.23 0.09	14.6 0.7		
638.99 0.05	100 1.9		

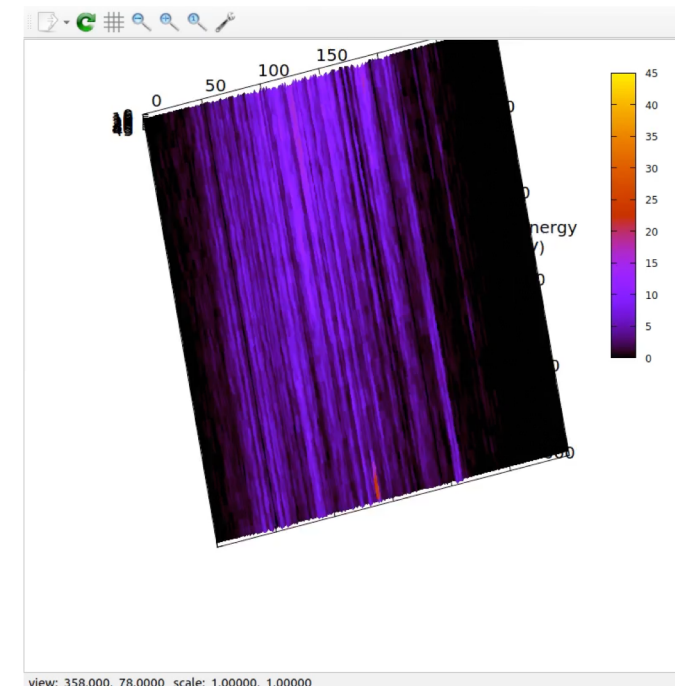
E(level): Energy (keV) Page Size: 10

# CouchDB provides efficient search / filter with “Views”

## Example



**Pre-populated once for fast result**



Coupling views with python plotting



Edwin Gomez

# API and Python Plotting

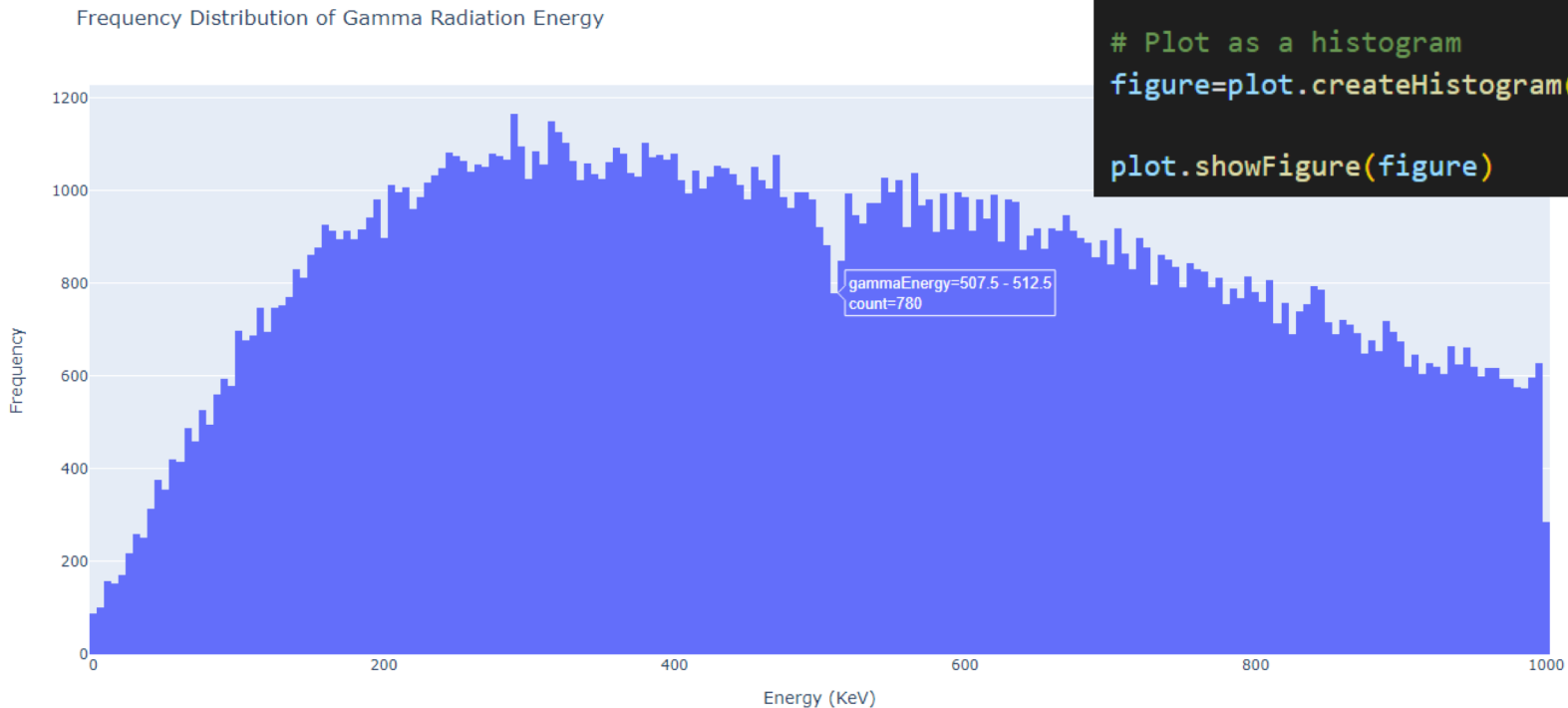
```
# Initialize API
api = ensdfAPI(ipAddress="127.0.0.1", port=5001)

# Get all gammas 0-1000 keV
values_dict=api.filterByGammas(0,1000)
dataframe = plot.createViewDataFrame(values_dict)

# Label plot
plot.configuration.setAxisTitle("x", "Energy (KeV)")
plot.configuration.setAxisTitle("y", "Frequency")
plot.configuration.setTitle("Frequency Distribution of Gamma Radiation Energy")

# Plot as a histogram
figure=plot.createHistogram(dataframe, "gammaEnergy")

plot.showFigure(figure)
```



# Summary and outlook

- Good progress on modernizing the ENSDF format
  - ✓ Adopted Levels/Gammas
  - ✓ Neutron-induced reactions
  - ✓ (HI,XN)
- Stay tuned for beta version this year
- User comments, questions, suggestions, concerns appreciated

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[cmorse@bnl.gov](mailto:cmorse@bnl.gov)

