



# Workflow of ENSDF evaluation with ENSDF Java codes

Jun Chen

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**MICHIGAN STATE**  
UNIVERSITY



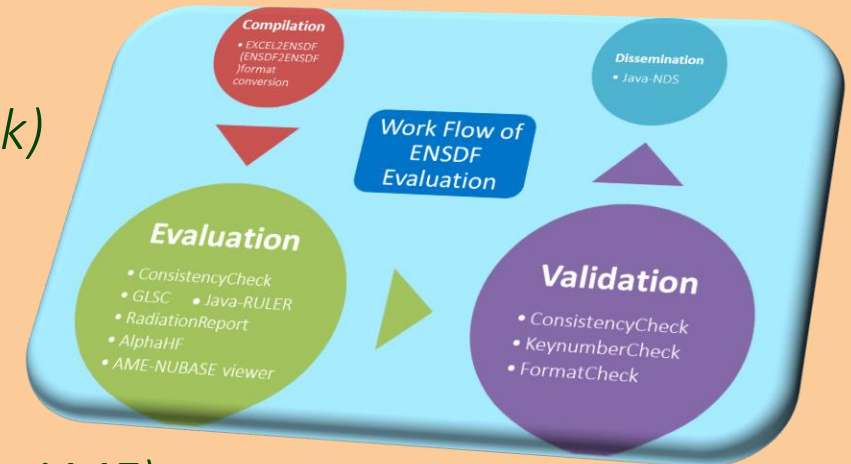
U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

# ENSDF code development and modernization at FRIB

To streamline and automate evaluation process, ensure evaluation quality and improve evaluation efficiency

- *McMaster-MSU Java-NDS* (constantly improved)
- *ConsistencyCheck* **NEW feature** (add format and keynumber check)
- *KeynumberCheck* (included in *ConsistencyCheck*)
- *Java-RULER* **NEW improvement** (improved *B(XL)* calculator tool)
- *Excel2ENSDF* **NEW improvement** (improved operations on records)
- *AME-NUBASE viewer* **NEW improvement** (improved calculator tool using AME)
- *GLSC* (Gamma to Level Scheme Computation: *GTOL+GABS*) **NEW improvement** (output with new *E(level)*, %IB, %IG for decay)
- *RadiationReport* (*LOGFT+RADLIST*) **NEW feature** (added calculators for logft from feeding or vice-versa)
- *AlphaHF* (*ALPHAD+RadD*)
- *FormatCheck* **NEW** (same checking function is also included in *ConsistencyCheck*)



# Setup of an ENSDF mass-chain evaluation

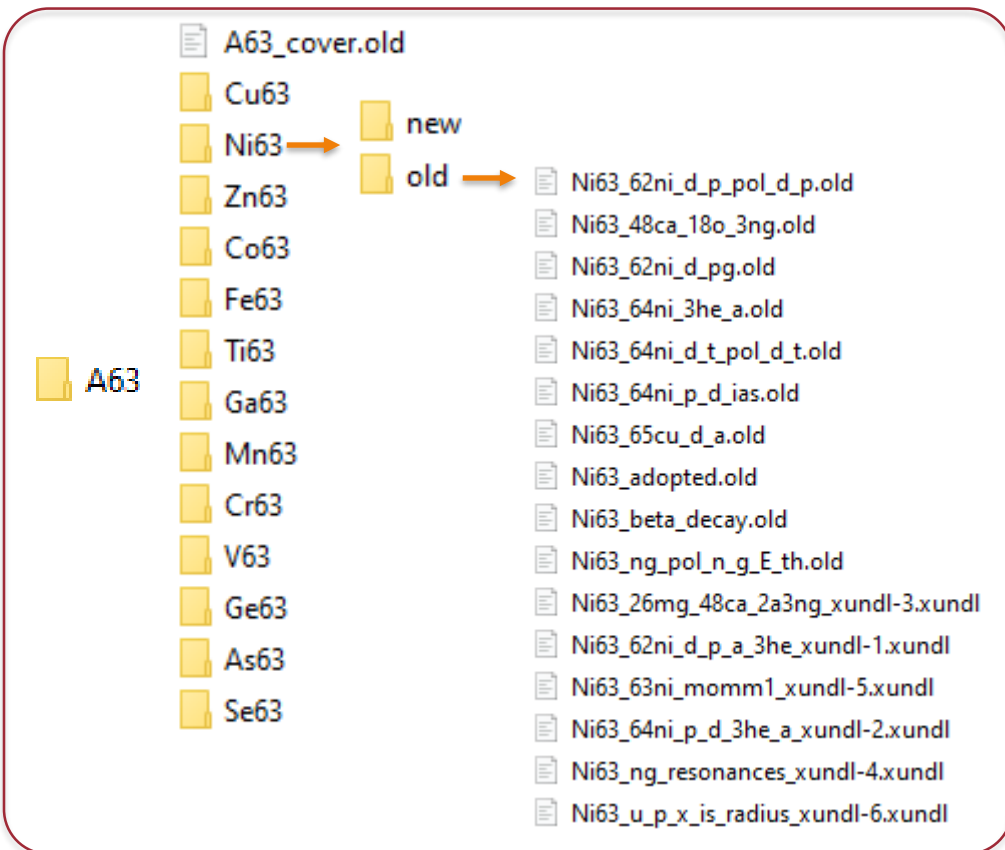
Setup

Compilation

Evaluation

Validation

Dissemination



Automatic setup of evaluation folders and datasets

Step 1: download all A=63 datasets from ENSDF database as A63.old

Step 2: load A63.old into *Java-NDS*

Step 3: choose a directory for A63 evaluation folder

Output path: H:\work\evaluation\ENSDF\check

Browse

Step 4: right-click on a blank area and click “setup evaluation folder” in the popup

Load ENSDF File

Create LaTeX File

Global Settings

Create PDF

Create PDF with auxiliary files

Split and Save datasets

Setup evaluation folder

Repeat for  
XUNDL datasets

Or, simply split the whole mass chain to files of individual datasets in one folder

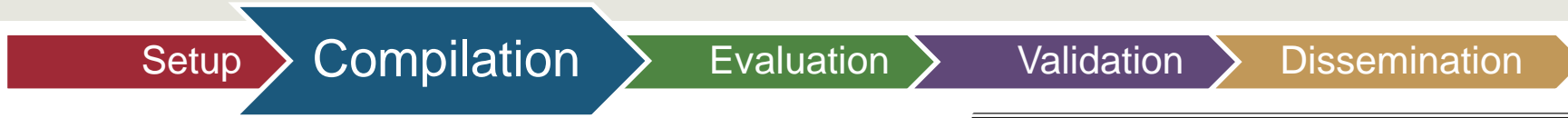
Create PDF



Create PDF with auxiliary files

Split and Save datasets

Setup evaluation folder

# Compilation: converting tabulated data to ENSDF



Step 1: scan data tables in a paper using a commercial OCR like  or a free OCR like  Save data into a Excel file

Step 2: edit and format the Excel table (rename column) for *Excel2ENSDF* to read

Step 3: load the Excel table into the *Excel2ENSDF*

Step 4: if E(level) are not given, load a reference dataset (e.g., adopted from ENSDF) for level matching

Step 5: convert it to an ENSDF-format dataset file default output: *output.ens*

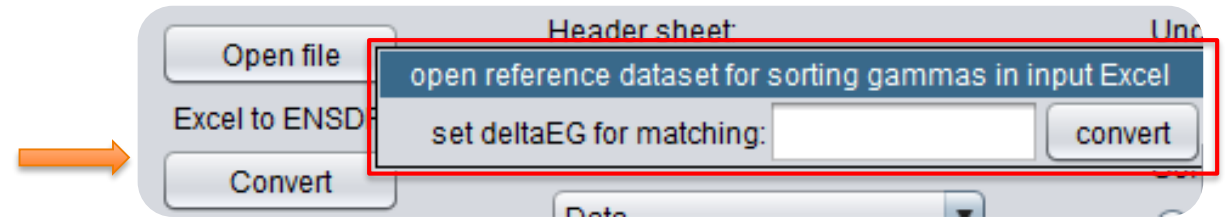
$E_i^\#$ (keV)	$E_\gamma$ (keV)	$I_i \rightarrow I_f$	$I_\gamma^\dagger$	$R_{DCO}$	$\Delta_{asym}$	$\delta_{E2/M1}$	$E\lambda/M\lambda$
708.7 (1)	708.7 (1)	$2^+ \rightarrow 0^+$	100.0 (5.2)	1.02 (10) <sup>a</sup>	0.12 (1)	-	E2
1391.4 (2)	682.4 (3)	$2^+ \rightarrow 2^+$	9.28 (47)	0.96 (11) <sup>b</sup>	-0.07 (3)	2.5	M1+E2
	1391.2 <sup>b</sup> (5)	$2^+ \rightarrow 0^+$	0.12 (3)	-	-	-	-
1483.5 (2)	774.8 (1)	$4^+ \rightarrow 2^+$	84.7 (86)	0.98 (9) <sup>b</sup>	0.14 (1)	-	E2
1794.6 (2)	310.9 (3)	$3^+ \rightarrow 4^+$	0.91 (13)	0.63 (8) <sup>b</sup>	0.09 (5)	3.0	M1+E2

Data table in the pdf of a paper

Excel table ready for conversion



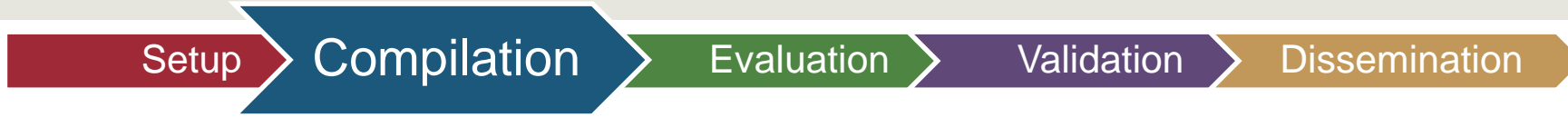
	A	B	C	D	E	F	G	H	I	J	K	L
1	EL	EG	JPI	JF	RI	DCO	POL	MR	MUL	GFLAG	LFLAG	BAND
2	708.7 (1)	708.7 (1)	2+	0+	100.0 (52)	1.02 (10)	0.12 (1)		E2	A		M
3	1391.4 (2)	682.4 (3)	2+	2+	9.28 (47)	0.96 (11)	-0.07 (3)	2.5	M1+E2	B		R
4		1391.2(5)	2+	0+	0.12 (3)					I		R
5	1483.5 (2)	774.8 (1)	4+	2+	84.7 (86)	0.98 (9)	0.14 (1)		E2	B		M
6	1794.6 (2)	310.9 (3)	3+	4+	0.91 (13)	0.63 (8)	0.09 (5)	3.0	M1+E2	B		U
7		403.1 (3)	3+	2+	0.78 (8)	0.56 (8)	0.16 (9)		M1+E2	B		U
8		1086.1 (2)	3+	2+	4.11 (42)	0.82 (10)	0.04 (2)	0.29	M1+E2	B		U



Right-click on "Open"

Open a reference dataset for matching and placing gammas in input Excel file with no levels being given

# Compilation: editing/merging ENSDF data with Excel



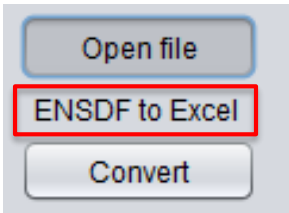
*Excel2ENSDF* also reads an ENSDF dataset and converts it to an Excel table

## ENSDF to Excel

Just load the ENSDF dataset and it will automatically recognize it.

```
63NI L 87.22 5/2-
63NI DL E LEVEL ENERGY HELD FIXED IN LEAST-SQUARES ADJUSTMENT
63NI cL E, J$from Adopted Levels
63NI L 1291.93 10 9/2+ E
63NI G 1204.7 1 0+Q
63NI2 G A2=+0.39 1 6 A4=-0.07 3
63NI cG 6R(-AC)=-1.33 {I7}
63NI L 2183.46 14 11/2+ E
63NI G 891.5 1 93.6 28 D+Q Y
63NI2 G A2=+0.15 1 6 A4=-0.14 1
63NI cG 6R(-AC)=-1.24 {I6}
63NI L 2813.59 17 13/2+ E
63NI G 630.1 1 100.0 34 D+Q Y
63NI2 G A2=-0.07 3 6 A4=-0.07 4
63NI cG 6R(-AC)=-1.07 {I3}
63NI G 1521.9 4 40.0 23 Q
63NI2 G A2=+0.17 1 6 A4=-0.19 2
63NI cG 6R(-AC)=-0.96 {I7}
```

A	B	C	D	E	F	G	H	I	J	K
EL	JPI	LFLAG	BAND	CL	ELI	JJ	ELF	JF	EG	RI
87.22	5/2-			E, J\$from Adopted Levels	1291.93(10)	9/2+	87.22	5/2-	1204.7(1)	
1291.93(10)	9/2+	E	E		2183.46(14)	11/2+	1291.93(10)	9/2+	891.5(1)	93.6(28)
2183.46(14)	11/2+	E	E		2813.59(17)	13/2+	2183.46(14)	11/2+	630.1(1)	100.0(34)
2813.59(17)	13/2+	E	E							
					2813.59(17)	13/2+	1291.93(10)	9/2+	1521.9(4)	40.0(23)
3650.41(19)	15/2+	E	E		3650.41(19)	15/2+	2813.59(17)	13/2+	836.8(1)	71.1(27)
					3650.41(19)	15/2+	2183.46(14)	11/2+	1467.6(3)	23.7(27)
4323.25(21)	17/2+	E	E		4323.25(21)	17/2+	3650.41(19)	15/2+	672.8(1)	60.5(25)
					4323.25(21)	17/2+	2813.59(17)	13/2+	1510.8(3)	24.8(18)
4569.17(23)	15/2+				4569.17(23)	15/2+	3650.41(19)	15/2+	919.9(2)	26.3(12)
					4569.17(23)	15/2+	2813.59(17)	13/2+	1755.4(2)	37.5(12)
4870.8(6)	17/2+	B	B		4870.8(6)	17/2+	2813.59(17)	13/2+	2058.3(4)	11.7(16)
5290.36(29)	(17/2+)	C	C	J\$967g(lq)	5290.36(29)	(17/2+)	4323.25(21)	17/2+	967.1(2)	16.1(31)
5539.20(25)	19/2+				5539.20(25)	19/2+	4569.17(23)	15/2+	969.7(3)	19.9(18)
					5539.20(25)	19/2+	3650.41(19)	15/2+	1888.9(2)	38.1(16)



label after an ENSDF is loaded

- ❑ Extracts ENSDF data into tabulated data for different uses
- ❑ Enables side-by-side (column) comparison and check for values of different datasets, e.g., gamma-ray energies, intensities
- ❑ Enables flexible and fast data editing with Excel, e.g., to remove (add) values of a record, simply delete (insert) its column in Excel then convert the table back to ENSDF

Default output: *output.xls*

- Includes everything from the dataset: data values and comments
- Can be converted back (~100%) to the original ENSDF dataset



# Evaluation: a least-squares fit to $E_\gamma$ values

Setup

Compilation

Evaluation

Validation

Dissemination

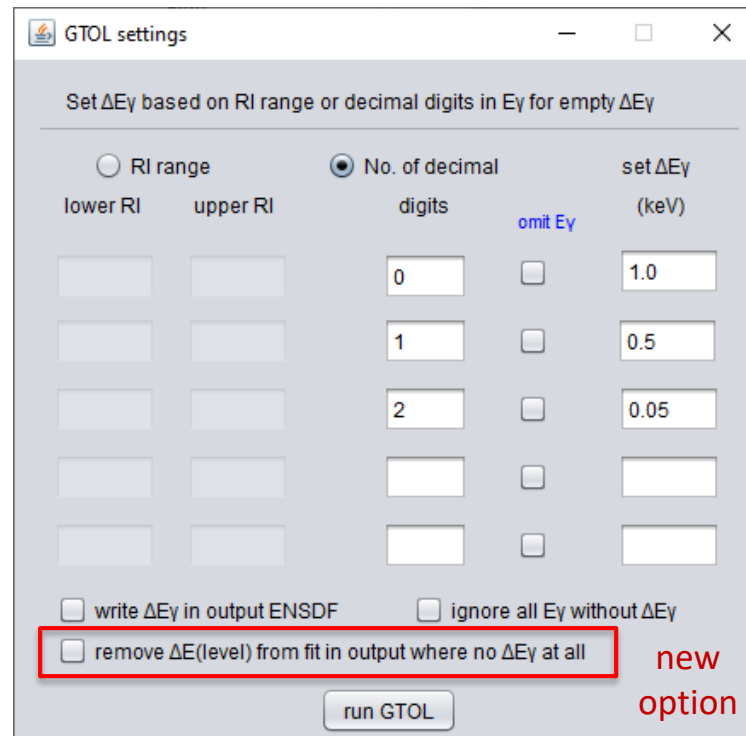
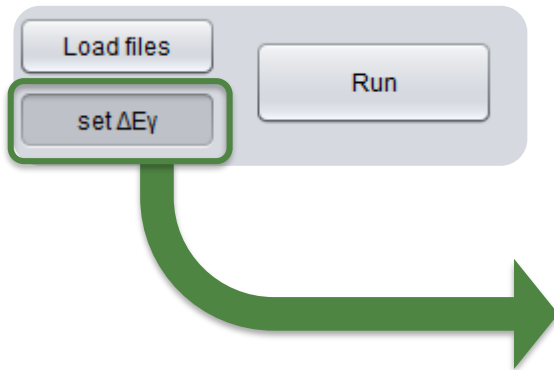
**GLSC** (*Gamma To Level Scheme Computation*) computes  $E(\text{level})$  based on input  $E_\gamma$  values and uncertainties and it uses assumed uncertainties if not given.

Provides an option for auto-adjustment of  $\Delta E_\gamma$  of poor-fitted ( $E_\gamma$ ,  $\Delta E_\gamma$ ) pairs

auto-adjust  $\Delta E_\gamma$  of poor-fit  $E_\gamma$  to reduce  $\chi^2/\text{ndf}$  to less than 2.0      Max good-fit #sigma: 2

In GLSC main window

In GLSC main window



Set $\Delta E_\gamma$ based on RI range or decimal digits in $E_\gamma$ for empty $\Delta E_\gamma$		
<input type="radio"/> RI range	<input checked="" type="radio"/> No. of decimal digits	set $\Delta E_\gamma$ (keV)
lower RI	upper RI	omit $E_\gamma$
	0	<input type="checkbox"/> 1.0
	1	<input type="checkbox"/> 0.5
	2	<input type="checkbox"/> 0.05
		<input type="checkbox"/>
		<input type="checkbox"/>

write  $\Delta E_\gamma$  in output ENSDF       ignore all  $E_\gamma$  without  $\Delta E_\gamma$

remove  $\Delta E(\text{level})$  from fit in output where no  $\Delta E_\gamma$  at all      **new option**

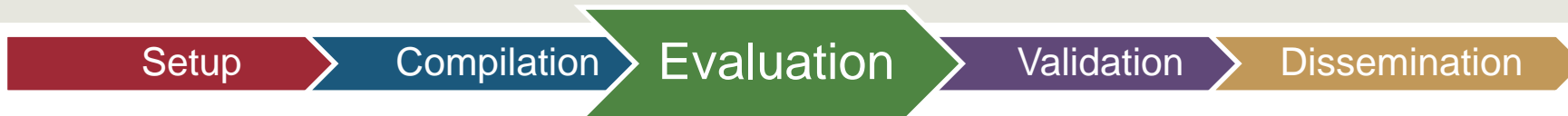
run GTOL

- Customized settings of  $\Delta E_\gamma$  if not explicitly given
- New option for removing  $\Delta E(\text{level})$  in the output, if there is not any full path of ( $E_\gamma$ ,  $\Delta E_\gamma$ ) pairs connected to a fixed level (e.g., ground state) (this is determined by the code)

A simple case: all decaying and feeding gammas has no  $\Delta E_\gamma$

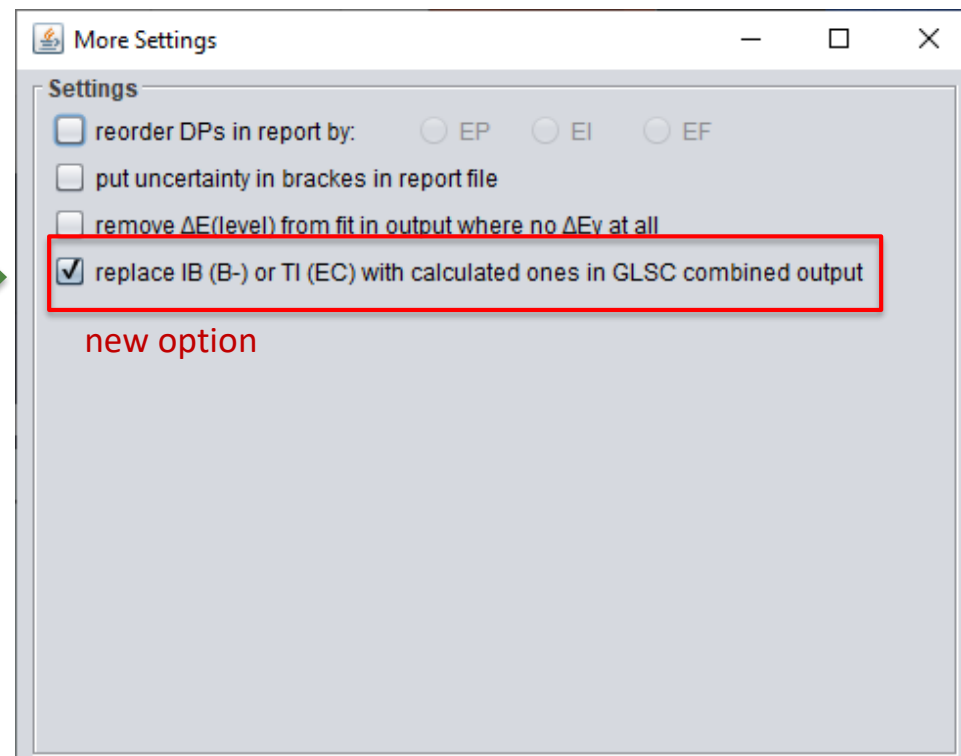
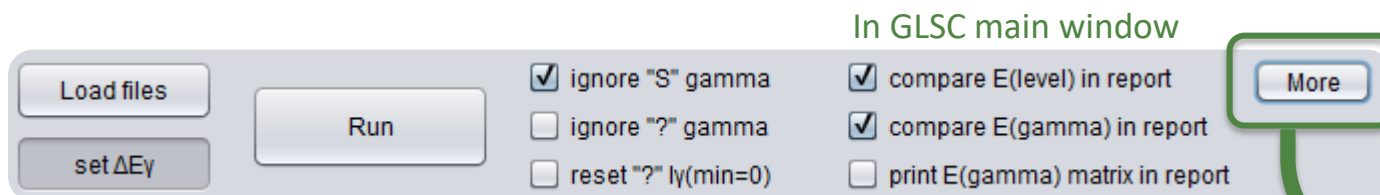


# Evaluation: new E(level), %I $\beta$ , %I $\gamma$ in one output



**GLSC** also computes I $\gamma$  normalization, level feedings (%I $\beta$ ) based on I( $\gamma$ +ce) intensity balances, and %I $\gamma$  for decay datasets.

**Provides** an option for making an output combining E(level) from fitting, computed %I $\beta$  (in IB record or TI for EC) and %I $\gamma$  (in %IG continuation record) in one run

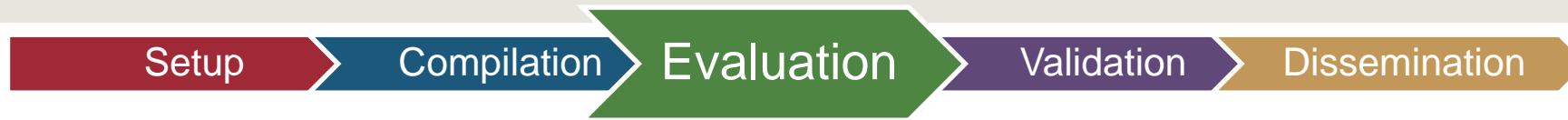


One run gets and combines GTOL+GABS results in one output output file: **GLSC\_combined.out**

Computed %I $\beta$  is simply from I( $\gamma$ +ce) intensity balance and will overwrite the existing value and uncertainty. It must be checked and verified the new value and uncertainty are not unexpected (e.g., numbers, uncertainty format) before adopting them.

Particularly, g.s. feeding, which might be expected to be obtained differently.

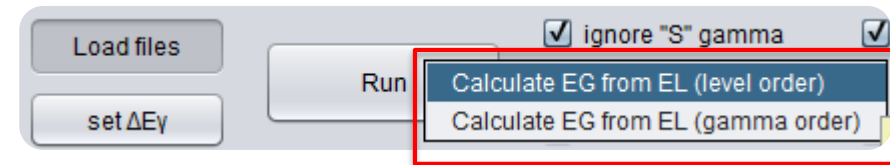
# Evaluation: a tool to get $E_\gamma$ from level-energy difference



Scenarios when  $E_\gamma$  needs to be calculated from level-energy difference:

- ❑ All E(level) values are precise with uncertainties but  $E_\gamma$  values are rounded numbers. **All  $E_\gamma$  should be re-calculated from level-energy difference**
- ❑ Some  $E_\gamma$  values are precise with uncertainties and some are rounded numbers. E(level) can be obtained from a fit to those precise  $E_\gamma$  values. **Those rounded  $E_\gamma$  values should be re-calculated from level-energy difference**

**GLSC** has a tool to calculate  $E_\gamma$  with no uncertainty from level-energy difference between its initial and final level energies if they have uncertainties.



In **GLSC** main window, right click "Run" button to get the popup

Output files:

**calcEG.rpt**: contains all details about each gamma

##Gamma	EG(calc)	EG(input)	Gamma energies calculated from level-energy differences (ordered by EL)							MULT	FLAGS
			diff.	RI	EI	EF	JI	JF			
#1	29.656 8	29.66 1	-0.00	420 36	29.656 8	0.0	5/2+	5/2-	E1	d	
#2	4.260 11	4.251	0.01		33.916 8	29.656 8	7/2+	5/2+	E1	d	
#3	33.916 8	33.91 1	0.01	81 8	33.916 8	0.0	7/2+	5/2-	E1	d	
#4	24.623 12	24.63 1	-0.01		58.539 9	33.916 8	9/2+	7/2+	M1+E2	bd	
#5	28.883 12	28.88 1	0.00		58.539 9	29.656 8	9/2+	5/2+	E2	bd	
#6	20.140 14	20.19 3	-0.05		78.679 10	58.539 9	7/2-	9/2+	E1	bX	
#7	44.763 13	44.77 2	-0.01	29 7	78.679 10	33.916 8	7/2-	7/2+	E1	d	
#8	49.023 13	49.02 2	0.00		78.679 10	29.656 8	7/2-	5/2+	E1	bd	
#9	78.679 10	78.67 2	0.01	35 4	78.679 10	0.0	7/2-	5/2-	E2 (+M1)	d	
#10	67.379 23	67.37 2	0.01	11.9 14	125.918 21	58.539 9	11/2+	9/2+	M1+E2	d	
#11	92.002 23	92.05 7	-0.05	5.0 15	125.918 21	33.916 8	11/2+	7/2+	[E2]	x	

**calcEG.out**: a new dataset with new  $E_\gamma$  from level-energy difference (**only those  $E_\gamma$  values with no uncertainties are overwritten**).



# Evaluation: a tool to average values in comments



*ConsistencyCheck* has a handy tool for extracting data values in an ENSDF comment (or *any free-format text*) and calculating their average

- Merge input files into a single file
- Save datasets to individual files
- Save datasets to files by nuclide
- Create new Adopted Dataset
- Create a combined dataset
- Clean up input ENSDF files
- Convert RI for Adopted
- Average values in comments
- Open Setup and Merging Tools
- Open average tool window**
- Open 80-column wrapping tool

In *ConsistencyCheck* main window, right click a blank area to get the popup

Average values listed in an averaging comment

63CU cL T\$weighted average of 0.57 ps {I7} from (Ia,p|g) by DSAM, 1.9 ps {I+6-3} from (Ia,pn|g) by DSAM, 0.57 ps {I3} from (I|g,g') by nuclear 63CU3cL resonance fluorescence, 0.52 ps {I+24-17} from (d,{+3}He|g) by DSAM, 63CU4cL and 0.61 ps {I4} from Coulomb excitation by DSAM. Other: 0.54 ps 63CU5cL {I+7-6} from B(E2)|^A=0.0355 {I16}

editable area for adding, removing, editing, copying/pasting data values

average    clear    Uncertainty Limit     25     35     99     other

```

----- average T-----
Data points of T record
*      (Ia,p|g) by DSAM   0.57 (7)      weight=10.37%
*      (Ia,pn|g) by DSAM  1.9(+6-3)   weight=0.24%
*              (I|g      0.57 (3)      weight=56.44%
*      (d,{+3}He|g) by DSAM 0.52(+24-17) weight=1.20%
*      Coulomb excitation by DSAM 0.61 (4)      weight=31.75%

Averaging results:
      weighted average:   0.585 (23)      (internal)
                          0.585 (34)      (external)
                          chi**2/(n-1)=2.248 [critical=3.017]

      unweighted average: 0.83 (27)
      (of all values)     chi**2/(n-1)=0.356 [critical=3.017]

      suggested adopted result: 0.59 (4)
      (Weighted-Of-All)

### weighted average comment:
63CU cL T$weighted average of 0.57 ps {I7} from (Ia,p|g), 1.9 ps {I+6-3} from
63CU2cL (Ia,pn|g), 0.57 ps {I3} from (I|g,g'), 0.52 ps {I+24-17} from
    
```

- Takes any list of data points separated by “,”, “;”, or “and”, or combination. Each data point is like,
  - 1.9 ps {I+6-3} or 1.9 ps +6-3

(please let me know if you find a kind of format that can't be processed)

- New option to run V.AveLib and display its results (not default)

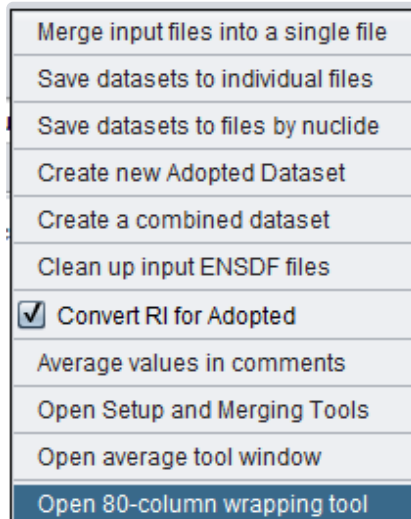
Just right click “average” to get all results



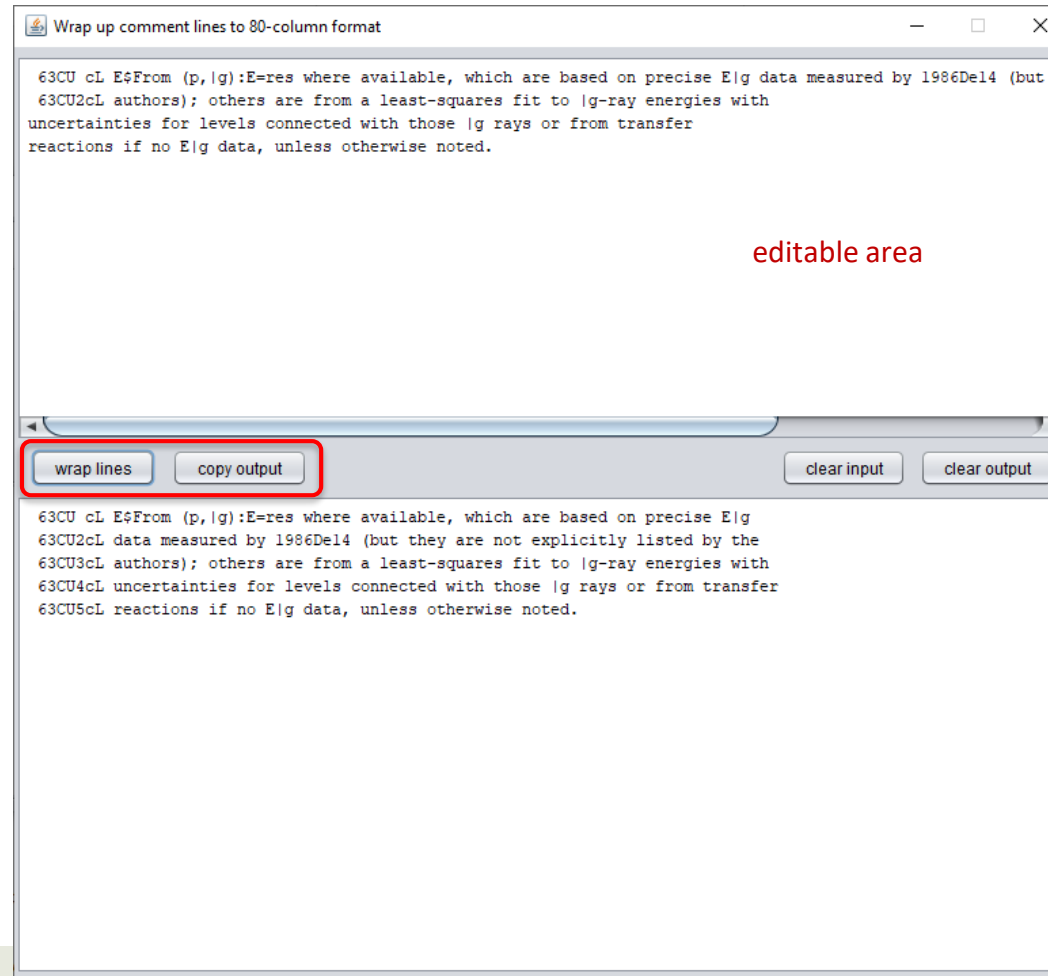
# Evaluation: a tool to edit and wrap an ENSDF comment



*ConsistencyCheck* has a handy tool for editing and wrapping a long ENSDF comment to 80-column format with ease



In *ConsistencyCheck* main window, right click a blank area to get the popup



- ❑ Useful for editing a long ENSDF comment without worrying about the 80-column limit (when using a text editor)
- ❑ New 80-column formatted comment is ready to be copied and pasted back into an ENSDF dataset

# Evaluation: a tool to calculate a single B(XL)

Setup

Compilation

Evaluation

Validation

Dissemination

*Java-RULER* has a handy tool for calculating a single B(XL) based on a part of ENSDF record lines

Update Brccs in output path  
Set assumed uncertainties  
Set error-propagation limit  
Set number of samples for MCEP  
Set uncertainty limit for rounding  
Open display of MCEP plots  
Open calculator of T12 and MR

In *Java-RULER* main window, right click a blank area to get the popup

*Java-RULER* works on an ENSDF dataset to calculate B(XL)(W.u.) values and insert them into the output dataset. This is needed only for the “Adopted Levels, Gammas” dataset

load an ENSDF or copy and paste an ENSDF dataset into the text area below

```
63CU L 669.724 6 1/2- 0.200 PS 7
63CUX L XREF=BFGHIJLMNOPQRSTUVWXYZab
63CU2 L BE2=0.0116 6
63CU cL JgL(pol d, {+3}He)=1 from 0+; L-1/2 from analyzing powers
63CU cL Tweighted average of 0.215 ps [I22] from (la,p|g) by DSAM, 0.196 ps
63CU2cL (I7) from (lg,lg') by nuclear resonance fluorescence, and 0.22 ps [I2]
63CU3cL from Coulomb excitation by DSAM, 0.219 ps [I48] from (d, {+3}He|g) by
63CU4cL DSAM.
63CU cL BE2from Coulomb excitation. Other: 0.0098 [I34] from (e,e')
```

calculate  B(XL)  T12  MR Uncertainty Limit  35  99  other

```
63CU L 669.724 6 1/2- 0.200 PS 7
63CU G 669.35 22 100 M1+E2 0.106 5
--->gamma#1-1: EG=669.35 22 BR(%g)=100 BR(%g+fce)=100 Mult=M1+E2 MR=0.106 5 CC=0 (assumed)
Weisskopf single-particle B(XL) (s.p.) (down) and half-lives T1/2 (s.p.) in second:
(uncertainties in T1/2 are from uncertainty in EG)
L B(EL) sp B(ML) sp L T1/2(EL) sp T1/2 (ML) sp
1 1.0206E-02 1.7910E+00 1 1.4246E-15 14 7.343E-14 7
2 1.4890E-03 2.6124E-01 2 2.829E-10 5 1.4582E-8 24
3 2.3576E-04 4.1362E-02 3 8.559E-5 20 0.004412 10
4 3.9495E-05 6.9299E-03 4 38.37 12 1978 6
* <1> Use uncertainties from <TAYLOR EXPANSION> error propagation:
EL=669.724
EG=669.35 22 BR(%g)=100 BR(%g+fce)=100 Mult=M1+E2 MR=0.106 5 CC=0 (assumed)
T1/2 (g)=2.00E-13 7 (sec) T1/2 (g+ce)=2.00E-13 7 (sec)
BM1 (UP)=0.4335 152 BM1 (DOWN)=0.6502 228 BM1W=0.3631 127 (RUL=3)
BE2 (UP)=0.01560 156 BE2 (DOWN)=0.02340 233 BE2W=15.71 157 (RUL=300)
* <2> Use uncertainties from <MINIMUM and MAXIMUM> of each variable:
```

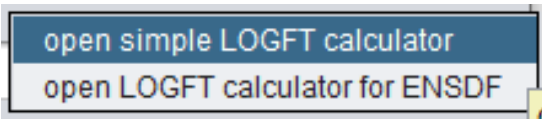
- Copy & paste ENSDF lines of a level and its gammas to be calculated for
- It also has options to calculate T1/2 or MR from measured B(XL)
- For calculations based on a B(XL)up value, the record line of its final level is also needed
- New improvement for extracting B(XL) values in comments

# Evaluation: a tool to calculate a single logft (1)



*RadiationReport* has a **new** handy tool for calculating a single B(XL) based on a part of ENSDF record lines

In *RadiationReport* main window, right click a blank area to get the popup



calculate logft of a final level

E(level)= 0.0      J<sup>π</sup>= 3/2-

%(total)= 83.4      6

logft= 5.403      4

calculate branching

For <sup>63</sup>Zn<sup>30</sup> EC/B+ decay to <sup>63</sup>Cu<sup>29</sup>

\*\*\* logft=5.4025(36)

\*\*\* logft=6.6425(32) (calculated as 1st Unique)

\*\*\* average decay energy=1040.12(97)

\*\*\* I(β<sup>+</sup>)=79.69(58)    I(ε)=3.712(46)

- A simple logft calculator for calculating a single logft based on parent and daughter level data **entered manually** or **loaded from an input dataset**
- It can also calculate a beta feeding for a given logft value
- It compares calculated logft with systematics and indicates possible decay types

\*\*\* uncertainties of results are in ENSDF style \*\*\*

Parent JPI=3/2-    final-level JPI=3/2-    \*allowed\*

Total decay energy	=3366.4	15	BR(%)=83.4	6	partial T1/2 (s)	=2769	20
End-of-point(B+)	EMAX	=2344.4	15				
Average energy(B+)	EAV	=1040.1	10	EAV/EMAX=0.4437	5		

EC/B+	=0.0466	5	log(EC/B+)	=-1.332	5	ECK/B+	=0.04129	17
ECK/(EC+B+)	=0.0395	4	ECL/(EC+B+)	=0.00431	5	EC(M+)/(EC+B+)	=7.52E-4	8
I(B+)	=79.7	6	I(EC)	=3.71	5			

log(t)	=3.4423	32	log(f0)	=1.9602	17
log(f0*t)	=5.403	4	f0*t	=2.527E5	21
log(f1*t)	=6.6425	32	(calculated as 1st forbidden unique)		

Systematics of logft values (2023TU02):

SUPERALLOWED DJ=0	DPI=NO	logft=3.17	to 3.53	
ISOSPIN FORBIDDEN DJ=0	DPI=NO	logft=6.66	to 10.92	
GAMOW-TELLER DJ=1	DPI=NO	logft=2.66	to 9.05 ***	
ALLOWED DJ=0	DPI=NO	logft=2.98	to 12.53 ***	
ALLOWED DJ=1	DPI=NO	logft=2.57	to 12.37 ***	
FIRST-FORBIDDEN NON-UNIQUE DJ=0	DPI=YES	2<80	logft=5.90	to 11.03
FIRST-FORBIDDEN NON-UNIQUE DJ=1	DPI=YES	2<80	logft=5.90	to 20.08
FIRST-FORBIDDEN UNIQUE DJ=2	DPI=YES		logft=8.50	to 12.78
SECOND-FORBIDDEN NON-UNIQUE DJ=2	DPI=NO		logft=10.92	to 14.23

\*\*\* indicates possible decay type based on calculated logft

*RadiationReport* works on an ENSDF decay dataset to calculate all radiations as well as logft values. Note that the recommended program for adopted logft is BetaShape.



# Evaluation: a tool to calculate a single logft (2)



*RadiationReport* has a **new** handy tool for calculating a single B(XL) based on a part of ENSDF record lines

In *RadiationReport* main window, right click a blank area to get the popup

open simple LOGFT calculator

open LOGFT calculator for ENSDF



Calculate logft of a dataset

load an ENSDF or copy and paste an ENSDF dataset into the text area below Col 2 clear

```

63CU 632N EC+B+ DECAY 1974KL02,1971GIZP,1969B015ENSDF 202309
632N P 0 3/2- 38.49 M 5 3366.4 15
63CU L 669.68 4 1/2-
63CU E 7.3 5 0.95 6 5.80 3 8.2 5
        
```

editable area

copy/paste here

1. DSID line
2. Parent record line
3. Level record line and its decay record line

calculate  Logft  BR Uncertainty Limit  35  99  other clear

For 632n30 EC/B+ decay to 63Cu29

```

*****
63CU L 669.68 4 1/2-
Parent JPI=3/2- final-level JPI=1/2- *allowed*
<old> 63CU E 7.3 5 0.95 6 5.80 3 8.2 5
<new> 63CU E 7.3 5 0.95 6 5.800 +26-28 8.2 5

Total decay energy =2696.7 15 BR(%)=8.2 5 partial T1/2 (s) =2.82E4 17
End-of-point(B+) EMAX =1674.7 15
Average energy(B+) EAV =732.4 8 EAV/EMAX=0.4373 6

EC/B+ =0.1315 14 log(EC/B+) =-0.881 5 ECK/B+ =0.1166 6
ECK/(EC+B+) =0.1030 11 ECL/(EC+B+) =0.01126 12 EC(M+)/(EC+B+) =0.001965 21
I(B+) =7.3 5 I(EC) =0.95 6

log(t) =4.449 27 log(f0) =1.3501 19
log(f0*t) =5.800 +26-28 f0*t =6.3E5 4

log(f1*t) =6.844 27 (calculated as 1st forbidden unique)

Systematics of logft values (2023TU02):
SUPERALLOWED DJ=0 DFI=NO logft=3.17 to 3.53
ISOSPIN FORBIDDEN DJ=0 DFI=NO logft=6.66 to 10.92
        
```

- Similar to Simple Calculator
- Easier usage by copy/paste

*RadiationReport* works on an ENSDF decay dataset to calculate all radiations as well as logft values. Note that the recommended program for adopted logft is BetaShape.



# Evaluation: a tool to calculate a single Hindrance Factor

Setup

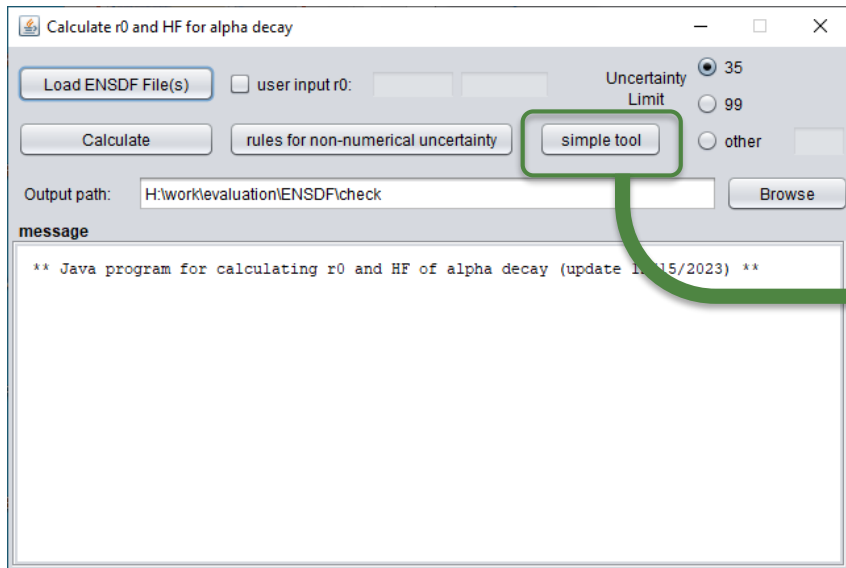
Compilation

Evaluation

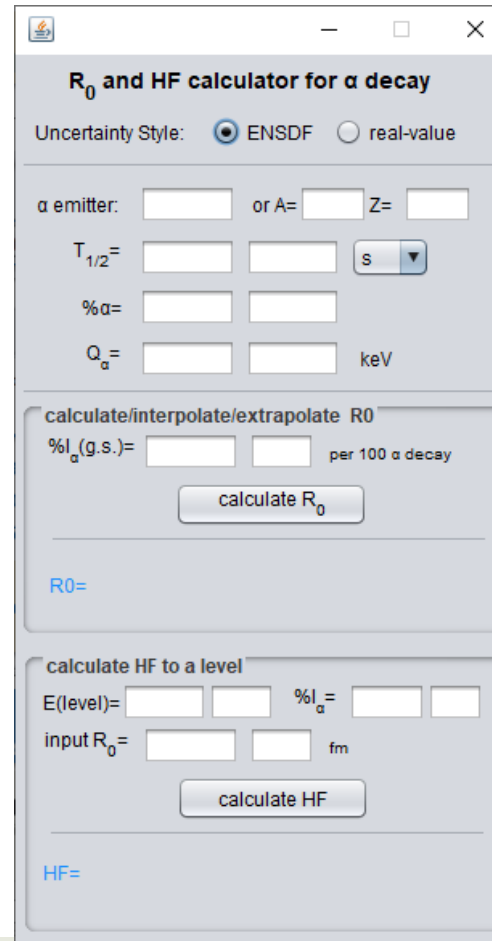
Validation

Dissemination

*AlphaHF* has a handy tool for calculating nuclear radius parameter  $r_0$  or HF for a single alpha-decay branch



*AlphaHF* works on an ENSDF alpha-decay dataset to calculate nuclear radius parameter  $r_0$  or Hindrance factors for all decay branches



## *AlphaHF*

- Alternative to ALPHAD for calculating HF
- Alternative to RadD for calculating or interpolating/extrapolating  $r_0$



# Evaluation: a tool to extract ce data for BriccMixing



Lots of ce data (conversion coefficients, subshell ratios, etc) are given in comments and evaluators are required to run BriccMixing with those data to get mixing ratio

*Excel2ENSDF* has a tool to extract ce data listed in each individual **gamma comment and continuation record** and write them into an output file in the format of input file for the BriccMixing program.

The output file can be read by the BriccMixing to calculate mixing ratio for each gamma listed in the file.

- extract and write ICC by Level
- extract and write ICC by Gamma
- Open tool for operation on Excel column
- Open tool for operation on ENSDF data

In *Excel2ENSDF* main window, right click a blank area to get the popup

```
167YB G 213.19 4 86 5M1 0.399 6 d
167YB2 G $IG=3.7 4
167YB cG $E|g=213.19 {I4}, I|g=86 {I5} (1975VyZY)
167YB cG $E|g=213.20 {I4}, I|g=39 {I2} (1976Me06)
167YB2 G EKC=0.36 7
167YB cG $K:L1:L2:L3=31 {I6}:4.13:0.41:<0.1 (1975VyZY)
167YB cG $K:L1:L2:L3=1.23:0.16:|?0.02:<0.01 (1971Ab04)
```

ce data in the continuation record and comment of 213-keV gamma in the input ENSDF dataset



extracted ce data entries that can be read by BriccMixing

```
*NEW-----
167YB G 213.19 4 86 5 M1 0.399
167YB 213.19 4
E1+M2 0 1
# NsrKey Shell IccVal Unc Type
Entry* K 0.36 7 A
Entry* L1/L3 41.0 82 R
1975VyZY* L1/L2 10.0 20 R
1971Ab04* L1/L2 8.0 16 R
Entry* L2/L3 4.10 82 R
1975VyZY* K/L2 76 15 R
1971Ab04* K/L2 62 13 R
Entry* K/L3 310 62 R
1975VyZY* K/L1 7.5 15 R
1971Ab04* K/L1 7.7 16 R
```

*ICC\_summary.rpt*

# Evaluation: batch operations on ENSDF records



Evaluators occasionally encounter situations like:

- ❑ All intensities need to multiply a factor
- ❑ All energies need to add a constant or append a text like "+SN"
- ❑ All values in A record need to move to B record
- ❑ All E(gamma) values need to be de-corrected for recoil energy
- ❑ Or, more complicated like: all "E(p)" placed in "S" record need to be converted to  $E(\text{level})=E(p)*\text{factor}+S(p)$  and then re-placed in level record

*Excel2ENSDF* has a tool to make batch operations on ENSDF records

- extract and write ICC by Level
- extract and write ICC by Gamma
- Open tool for operation on Excel column
- Open tool for operation on ENSDF data

In *Excel2ENSDF* main window, right click a blank area to get the popup

**Operation on record in an ENSDF dataset**

Uncertainty Limit:  35  99  [ ]

Operation on record: LEVEL EL

Add  Subtract  Multiply  Divide

Append (end)  Append (pre)  De-recoil EG

Replace  Use expression, like +1.23(4)\*0.23(4)

one operation for each record (last set)  
use expression for multiple operations

const or text for op: [ ] set

reset all e.g., 1.23(4) or +SN reset

Put result in field: EL same field by default

convert relative Ig to %BR from each level

Do operation

Record that need operation

Available operations

Set a new place for value after operation

# Evaluation: auto-grouping data of various reactions&decays



Ni63 new

- Ni63\_ng\_pol\_n\_g\_E\_th.ens
- Ni63\_adopted.ens
- Ni63\_beta\_decay.ens
- Ni63\_64ni\_3he\_a.ens
- Ni63\_48ca\_18o\_3ng.ens
- Ni63\_26mg\_48ca\_2a3ng.ens
- Ni63\_62ni\_d\_pg.ens
- Ni63\_64ni\_p\_d.ens
- Ni63\_62ni\_a\_3he.ens
- Ni63\_ng\_resonances.ens
- Ni63\_62ni\_d\_p\_pol\_d\_p.ens
- Ni63\_64ni\_d\_t\_pol\_d\_t.ens
- Ni63\_65cu\_d\_a.ens



```

LEVEL***** 63NI L 517.897 30 3/2-
*new XREF new tags 63NIX L XREF=AEFHJJKL
*new XREF old tags 63NIX L XREF=AEFHJJKL
#old XREF in Adopted 63NIX L XREF=AEFHJJKL
63CO B- DECA--->A A 63NI L 517.8 6 3/2-
62NI (N,G), (POL N,G) E=TH--->E E 63NI L 517.899 30 3/2-
62NI (D,P), (POL D,P) --->F F 63NI L 515 5 3/2-
62NI (A,3HE) --->H H 63NI L 518
64NI (P,D) --->I I 63NI L 518
64NI (D,T), (POL D,T) --->J J 63NI L 518 3/2-
64NI (3HE,A) --->K K 63NI L 518 3/2-
65CU (D,A) --->L L 63NI L 523 15
63CO B- DECA--->A A 63NI B 0.11 8.9 ?
62NI (N,G), (POL N,G) E=TH--->E E 63NI cL J$spin=3/2 also from |g|g(lq) in 1964Co13.
62NI (D,P), (POL D,P) --->F F 63NI cL E$others: 518 (1970Li03,1970Tu02,1977St07), 526 (1963Fu04).
62NI (D,P), (POL D,P) --->F F 63NI cL S$others: 0.34 (2013Sc06), 0.306 (1963Fu04), 0.276 (1977St07), 0.32
62NI (D,P), (POL D,P) --->F F 63NI2cL (1970Tu02).
64NI (P,D) --->I I 63NI cL S$other: 0.51 at 25|.
64NI (D,T), (POL D,T) --->J J 63NI cL S$other: 0.58 (1981B104).
64NI (3HE,A) --->K K 63NI cL E$other: 520 {I40} (1968Ru02).
64NI (3HE,A) --->K K 63NI cL S$other: 0.64 (1968Ru02).
GAMMA----- 63NI G 362.40 8 100 --- EG=362.40 FL=155.510 JF=3/2-
63CO B- DECA--->A A 63NI G 362.3 5 100 C *** EG=362.3 FL=155.55 JF=3/2-
62NI (N,G), (POL N,G) E=TH--->E E 63NI G 362.40 8 100 *** EG=362.40 FL=155.512 JF=3/2-
63CO B- DECA--->A A 63NI2 G %IG=0.107 22
62NI (N,G), (POL N,G) E=TH--->E E 63NI cG E$weighted average of 362.1 {I2} (1970GaZQ) and 362.42 {I5} (1992Ha21).
GAMMA----- 63NI G 430.71 5 2.4 --- EG=430.71 FL=87.220 JF=5/2-
62NI (N,G), (POL N,G) E=TH--->E E 63NI G 430.71 5 2.4 *** EG=430.71 FL=87.225 JF=
62NI (N,G), (POL N,G) E=TH--->E E 63NI cG E$other: 430.7 {I3} (1970GaZQ).
GAMMA----- 63NI G 517.61 31 30 6 --- EG=517.61 FL=0.0 JF=1/2-
62NI (N,G), (POL N,G) E=TH--->E E 63NI G 517.61 31 30 6 *** EG=517.61 FL=0 JF=1/2-
62NI (N,G), (POL N,G) E=TH--->E E 63NI cG E$unweighted average of 517.3 {I3} (1970GaZQ) and 517.91 {I4}
62NI (N,G), (POL N,G) E=TH--->E E 63NI2cG (1992Ha21).
    
```



**ConsistencyCheck** matches & groups levels and gammas from input datasets of various reactions and decays

All data and comments from various reactions and decays for a level (and its gammas) are gathered and seen in one screen. No need to jump across individual datasets back and forth.



# Evaluation: auto-making a preliminary Adopted dataset

Setup

Compilation

Evaluation

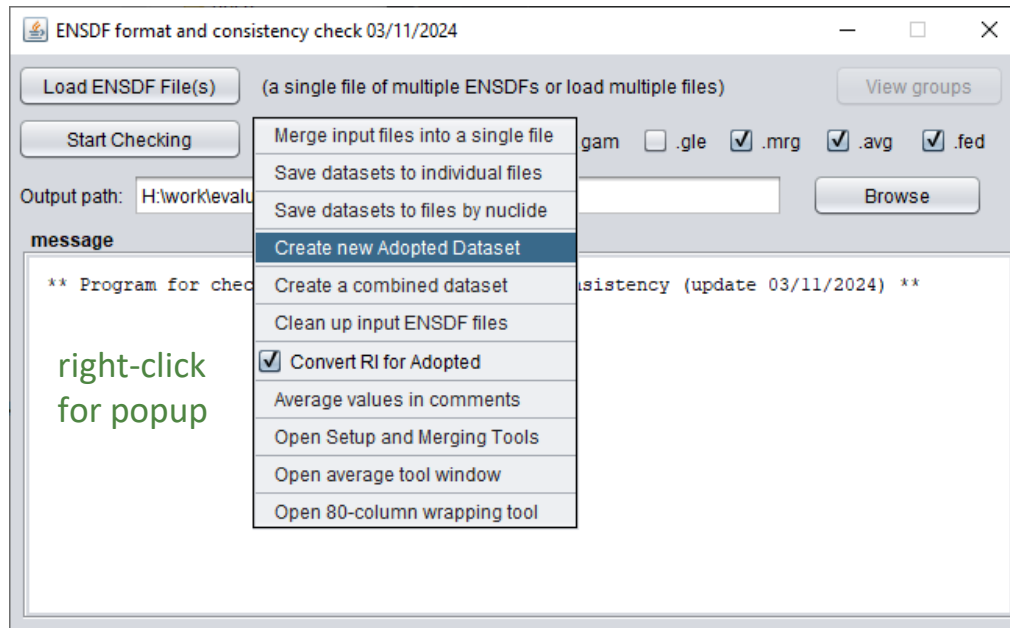
Validation

Dissemination

- Ni63
- new
- Ni63\_ng\_pol\_n\_g\_E\_th.ens
- Ni63\_adopted.ens
- Ni63\_beta\_decay.ens
- Ni63\_64ni\_3he\_a.ens
- Ni63\_48ca\_18o\_3ng.ens
- Ni63\_26mg\_48ca\_2a3ng.ens
- Ni63\_62ni\_d\_pg.ens
- Ni63\_64ni\_p\_d.ens
- Ni63\_62ni\_a\_3he.ens
- Ni63\_ng\_resonances.ens
- Ni63\_62ni\_d\_p\_pol\_d\_p.ens
- Ni63\_64ni\_d\_t\_pol\_d\_t.ens
- Ni63\_65cu\_d\_a.ens

```
63NI L 2183.5 3 (11/2+,13/2+) 3.6 PS 6
63NIX L XREF=BCL(2165*)
63NI cL J from {+48}Ca ({+18}O,3n|g) .
63NI G 891.56 10 100 D+Q D
63NI cG E$weighted average of 891.5 {I1} from ({+48}Ca,2|a3n|g) and 891.70
63NI2cG {I16} from ({+18}O,3n|g)
```

NOTE: this is only a very preliminary Adopted dataset with only an **initial assessment by the code**, which need to be checked and verified by the evaluator.

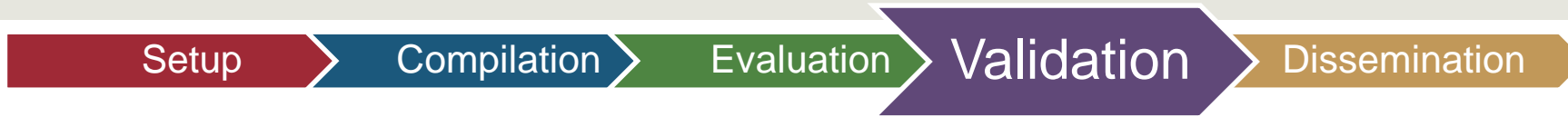


## ConsistencyCheck

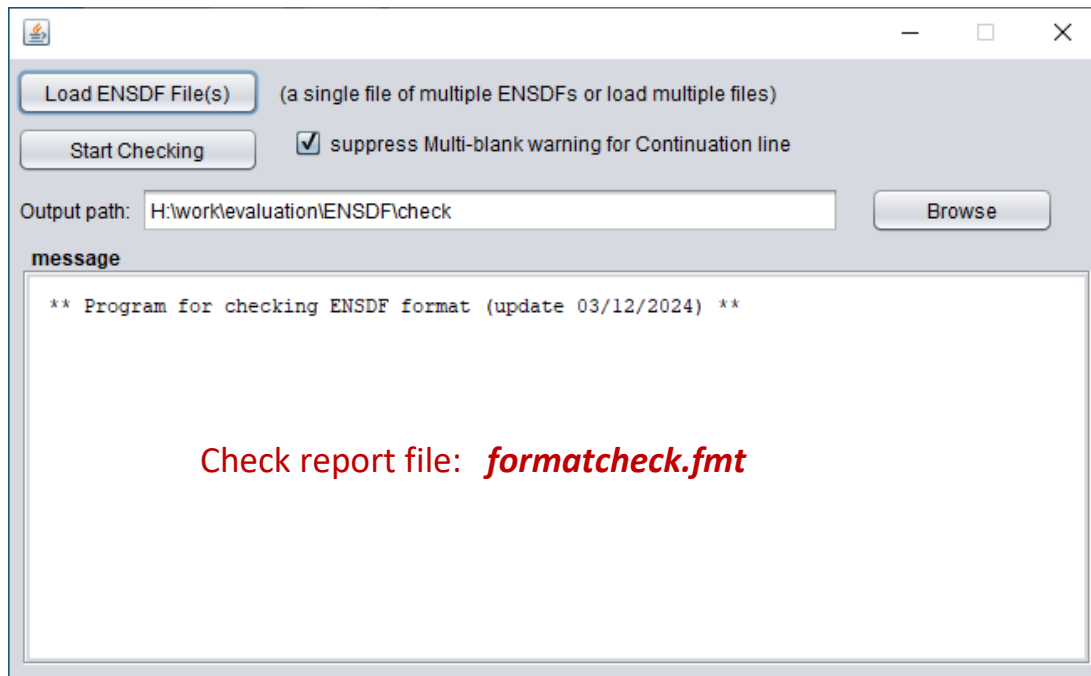
generates a preliminary new Adopted dataset combining all input data of various reactions and decays and selecting the best values from an initial **automatic** assessment for JPI, T1/2, EG, RI, MUL, MR

like automatically averaging of all available values (T1/2, EG, RI), generating needed comments, and placing them into the new dataset

# Validation: ENSDF format check



**FormatCheck:** a new ENSDF Java code to replace the legacy FMTCHK Fortran code that lacks of maintenance

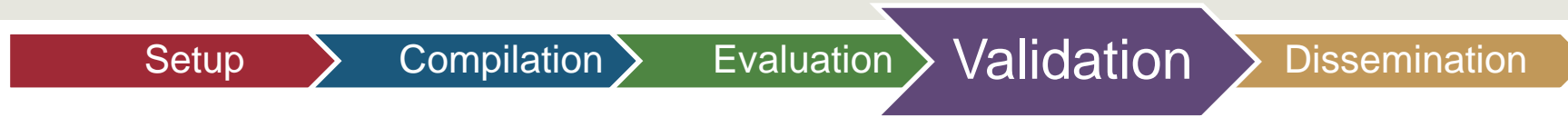


This is the stand-alone program for checking ENSDF format

- Includes all checking items (exceptions below) covered in FMTCHK (please let me know if some items are missing)
- Remove unneeded check items in FMTCHK due to file I/O restrictions, like end-of-file check
- Remove no-longer-correct error messages for outdated format requirements, like, in “XREF=L(3034\*)”, \* is marked as in error since it is expected to be like “(\*3034)”. Either is good now.
- Remove check for inconsistency, like unmatched DSIDs. Those are items checked by ConsistencyCheck but not format issues.
- Add lots of new check items (still growing), like unbalanced brackets (anywhere).

The same code is also integrated into ConsistencyCheck with its report file named like “63.fmt” for A=63 nuclides (for all checkings at one time)

# Validation: NSR keynumber check for format and relevance



**KeynumberCheck:** scan and check all **NSR keynumbers** or **keynumber-like** strings against **format errors** and **irrelevance**

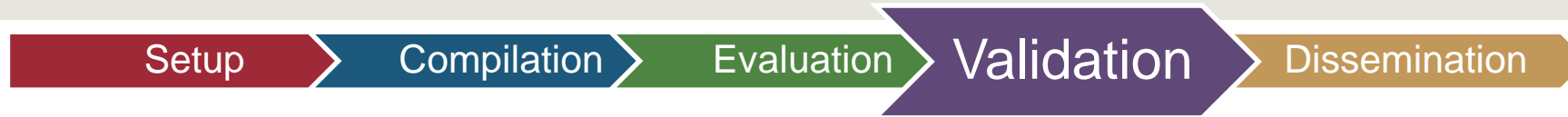
- ❑ **Format error** in keynumber is easy to be made but is also easy to be found (by the code)
- ❑ **Irrelevance check** is done through searching for close mass numbers in the NSR abstract retrieved on-the-fly from the NSR database for each valid keynumber.
  - It generates a list of “irrelevant” keynumbers but it is preliminary based on the current searching method
  - Evaluator must check and filter out those incorrectly selected as “irrelevant” by looking into the papers
- ❑ Normally, a few to tens of irrelevant keynumbers can be found in a mass chain evaluation. Those are mostly due to **misprint of one letter or one digit**.
- ❑ A stand-alone version is available, and it has also been **integrated into *ConsistencyCheck*** with its report file named like **“63\_keynumber.rpt”** for A=63 nuclides (for all checkings at one time)

example

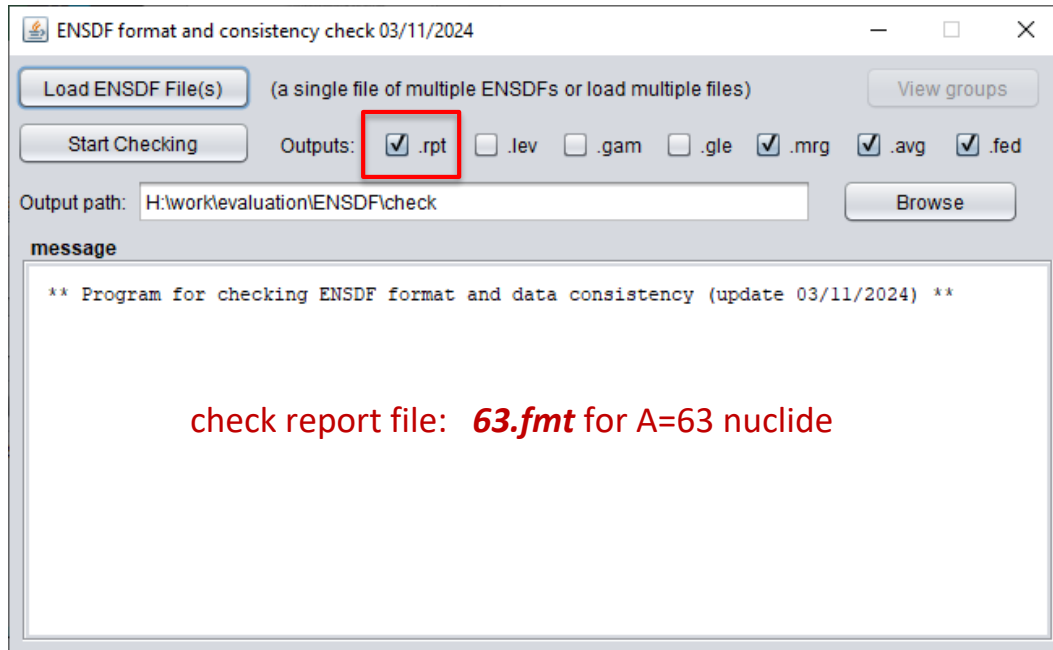
```
--- Line 712: ----- line#=49 in 156SM: 252CF SF DECAY  
1970Jo20 : <W> probably irrelevant. Check if typo.  
#title=Four-Parameter Measurements of Isomeric Transitions in  
{+252}Cf Fission Fragments
```



# Validation: in- and cross-dataset inconsistency check

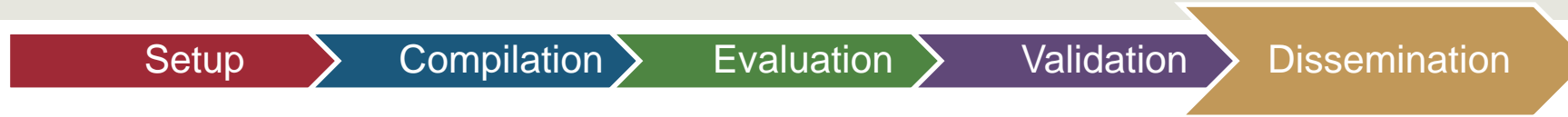


**ConsistencyCheck:** initially developed to check in- and cross-dataset inconsistencies, but has become a toolkit of many other checking and utility functions

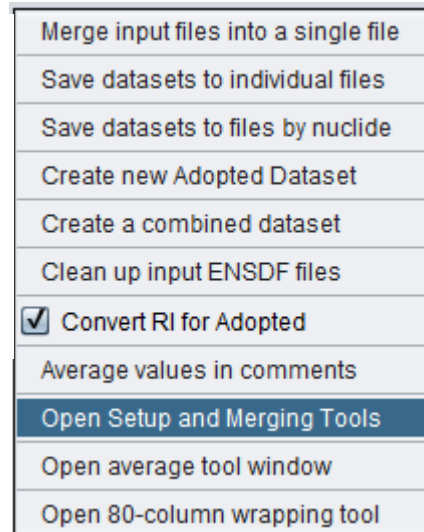


- ❑ Mostly found inconsistencies are those between JPI values in Adopted Levels and JPIs in individual datasets with comments saying those JPIs from Adopted Levels
- ❑ Similar inconsistencies are also easily made for adopted E(level),  $T_{1/2}$ , gamma branching ratios, etc., and are checked by this code.
- ❑ Inconsistencies in physics are also checked, for example like  $Mult=M1+E2$  for a transition from  $3+$  to  $2-$ . Many such possible physics inconsistencies are considered in the code and will be checked.
- ❑ Other possible inconsistencies: unmatched DSIDs in XREF list and source dataset, unmatched XREF tag in Adopted Levels, unmatched parent data with Adopted, etc.
- ❑ This code also digs into comments to search for inconsistently quoted values.

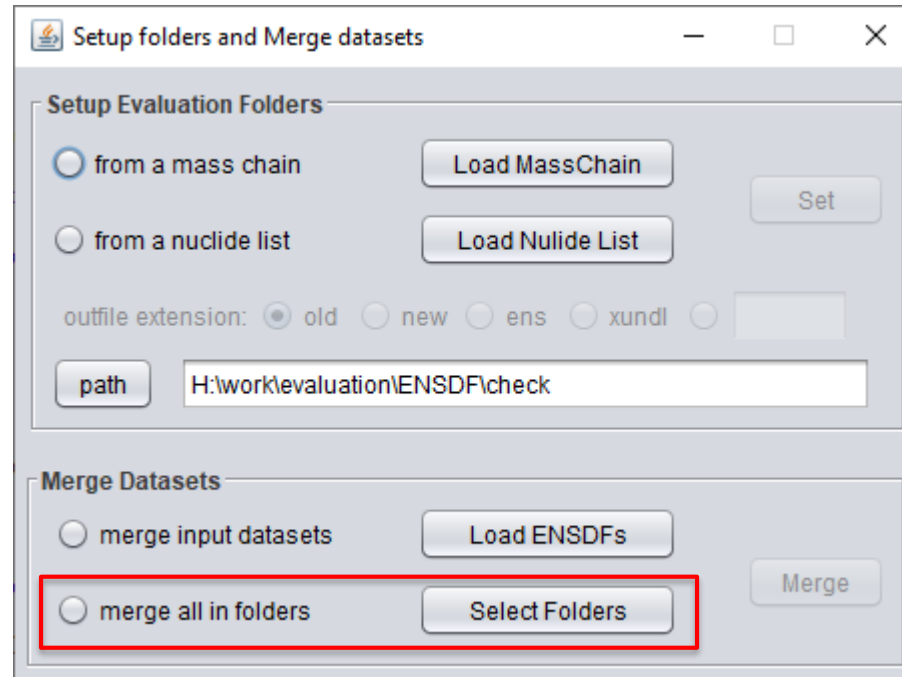
# Dissemination: merge all individual datasets



**ConsistencyCheck:** has a tool to merge all updated individual datasets in an evaluation folder into a single ENSDF file in order (the same order in the XREF list in Adopted Levels)



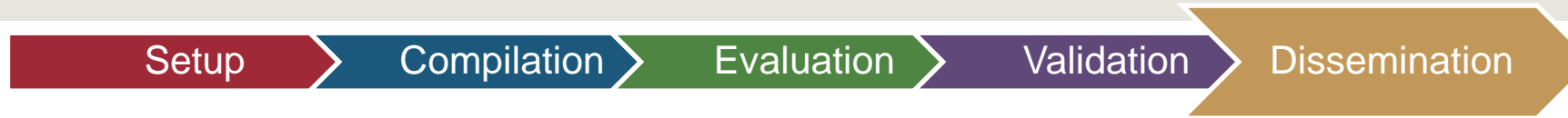
In **ConsistencyCheck** main window, right click a blank area to get the popup



Select the evaluation folder, e.g., A=63

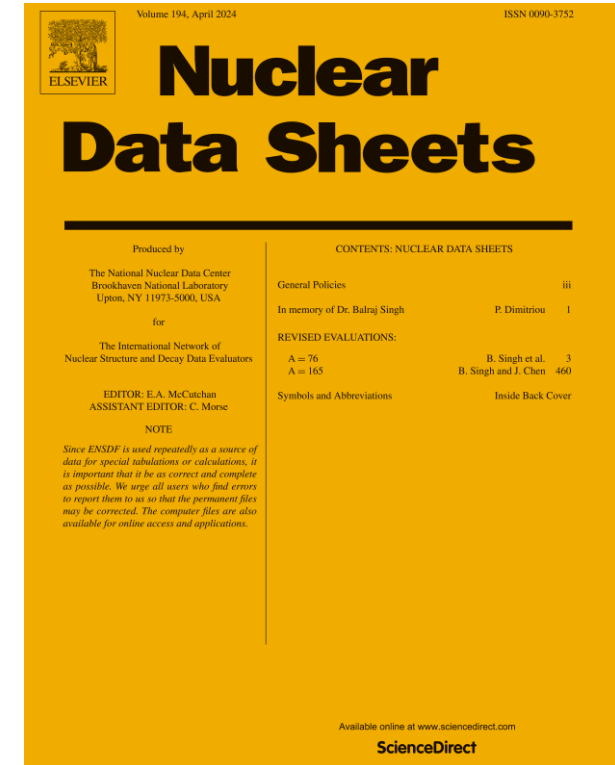
Output: "merged.ens"

# Dissemination: generate print-ready pdf from an ENSDF file



## McMaster-MSU Java-NDS:

- ❑ It is first officially released in 2017 for generating print-ready pdf from ENSDF datasets for the journal of Nuclear Data Sheets and online web display.
- ❑ It has been constantly maintained and improved based on evaluators' feedbacks.
- ❑ There is no major change since last release (v2.1 in December 2021), but it has been constantly updated with minor changes and bug fixes. The updated version is always uploaded to the NSDD GitHub in time (most recent version: **12March2024**).
- ❑ A test version of Java-NDS for the new JSON format is also available for testing. Please let me know if you are interested to get a copy to try.



All ENSDF Java codes can be found and downloaded at the NSDD GitHub for ENSDF Analysis and Utility Programs

<https://github.com/IAEA-NSDDNetwork>

