ENSDF Analysis & Utility Codes

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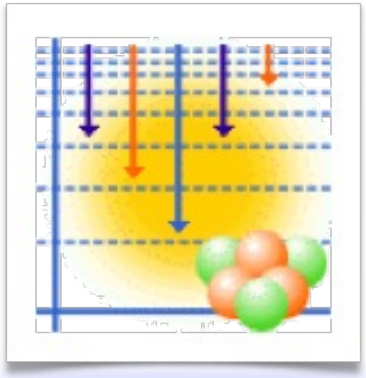

Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Theory, Experiment and Evaluation, Trieste IT 2022

https://www-nds.iaea.org/public/ensdf_pgm/
https://github.com/orgs/IAEA-NSDDNetwork/

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NNDC

Utility Codes:

- ✓ **fmtchk**
- ✓ **McMaster_MSU_JAVA-NDS**
- ✓ **AveTools** (V.AveLib)
- ✓ xls2ens – **Excel2ENSDF (new)**

Analysis Codes:

- ✓ alphad – **AlphaHF-test (new)**
- ✓ **gabs**
- ✓ **gtol – GLSC (new)**
- ✓ **logft**
- ✓ pandora **- ConsistencyCheck (new)**
- ✓ **ruler – Java-RULER (new)**
- ✓ radlist – **RadiationReport-test (new)**
- ✓ **BrIcc**
- ✓ **BrIccMixing**

fmtchk

how to run it (linux & MacOSX): **fmtchk filename.ens** -> creates fmtchk.rpt file

This program analyzes the format of an ENSDF formatted file to verify that it conforms to "EVALUATED NUCLEAR STRUCTURE DATA FILE. A Manual for Preparation of Data Sets" by J.K. Tuli, Brookhaven National Laboratory Report BNL-NCS-51655-01/02-Rev (February 2001) and subsequent memos.

Input file:
(Sample input file: fmtchk.inp)

An ENSDF-formatted file.

Output file:
(Sample output file: fmtchk.rpt)

A report file indicating possible errors or warnings is generated Brief explanations of the fatal error (prefix <F>), error (prefix <E>), warning (prefix <W>), and informational (prefix <I>) messages are listed below.

must be fixed!

```
        ....:....1....:....2....:....3....:....4....:....5....:....6....:....7....:....8

        ---------+---------+-+-------+-+-------+-+-------+-----+------+-+---------+-++-+

     1. 200PT    200IR B- DECAY               2013MO20                          201308
     2. 200PT c  {+200}Ir produced in fragmentation of {+208}Pb beam with E({+208}Pb)=1
     3. 200PT2c  GeV/A impinging on a 2.5 g/cm{+2} thick Be target. The beam was
     4. 200PT3c  provided by SIS-18 synchrotron at GSI facility. Residues of interest
     5. 200PT4c  were separated using Fragment Separator. Measured E|g, I|g, |g|g-coin,
     6. 200PT5c  |b|g-coin, fragment-|g correlated event using RISING array comprising
     7. 200PT6c  of 15 cluster HpGe detectors. Nine DSSSD detectors were used for
     8. 200PT7c  particle detection.
     9. 200PT cL $ The decay scheme is incomplete and, as a consequence, no |b{+-}
    10. 200PT2cL feedings and log {Ift} values are given. Apparent |b{+-} feedings that
    11. 200PT3cL were determined in 2013Mo20 are given as comments
    12. 200PT cL E$From a least-squares fit to E|g
    13. 200PT cL J$From Adopted Levels
    14. 200PT cG E,RI$From 2013Mo20
    15. 200IR  P 0.0         (1-)             43 S      6             5030      SY
    16. 200IR cP QP$ 5030 keV {I200} (syst, 2021Wa16)
    17. 200PT  N                        1
    18. 200PT cN NR$The decay scheme is incomplete and, as a consequence, no
    19. 200PT2cN normalization to absolute emission probabilities is given
    20. 200PT PN                                                                5
    21. 200PT  L 0.0         0+               12.6 H        3
    22. 200PT cL   T$From adopted levels
                  ***                                                                <E> INVALID FIELD NAME
    23. 200PT  L 470.1     12 2+
    24. 200PT cL $I{-{|b{+-}}}(apparent)=24% {I14} in 2013Mo20
    25. 200PT  G 470.1     12 100    7
    26. 200PT  L 867.5     16 (2)+
    27. 200PT cL $I{-{|b{+-}}}(apparent)<8% in 2013Mo20
    28. 200PT  G 397.3     16 42     3
    29. 200PT  L 1102.6    23 4+
    30. 200PT cL $I{-{|b{+-}}}(apparent)=13% {I4} in 2013Mo20
    31. 200PT  G 632.5     19 13.0   15
    32. 200PT  L 1181.1    15 (3)+
    33. 200PT cL $I{-{|b{+-}}}(apparent)=8% {I2} in 2013Mo20
    34. 200PT  G 313.7     14 7.5    9
    35. 200PT  G 711          2.5    6
    36. 200PT  L 1624.9    18
    37. 200PT cL $I{-{|b{+-}}}(apparent)=29% {I6} in 2013Mo20
    38. 200PT  G 757       2  12.4   16
    39. 200PT  G 1155.0    16 16     2
    40. 200PT  L 1690.4    24
    41. 200PT cL $I{-{|b{+-}}}(apparent)=9% {I3} in 2013Mo20
    42. 200PT  G 822.9     17 8.6    13
    43. 200PT  L 1730.4    14 (2+)
    44. 200PT cL $I{-{|b{+-}}}(apparent)=2.3% {I10} in 2013Mo20
    45. 200PT  G 1260.3    7  2.3    7
    46. 200PT  L 1833.4    19
    47. 200PT cL $I{-{|b{+-}}}(apparent)=2.2% {I9} in 2013Mo20
    48. 200PT  G 652.3     11 2.2    6

        ....:....1....:....2....:....3....:....4....:....5....:....6....:....7....:....8
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EVALUATED NUCLEAR STRUCTURE DATA FILE              SYNTAX CHECK          FMTCHK version 10.4d AS OF 29-Nov-2018     PAGE    2

        ....:....1....:....2....:....3....:....4....:....5....:....6....:....7....:....8
    49. 200PT  L 1850.4    22 (2+)
    50. 200PT cL $I{-{|b{+-}}}(apparent)=13% {I4} in 2013Mo20
    51. 200PT  G 982.9     15 13.3   18
                                                                                   <F> NO END CARD BEFORE END OF FILE
¶
EVALUATED NUCLEAR STRUCTURE DATA FILE              SYNTAX CHECK          FMTCHK version 10.4d AS OF 29-Nov-2018     PAGE    3
 X RECORD TO ID RECORD COMPARISON
```
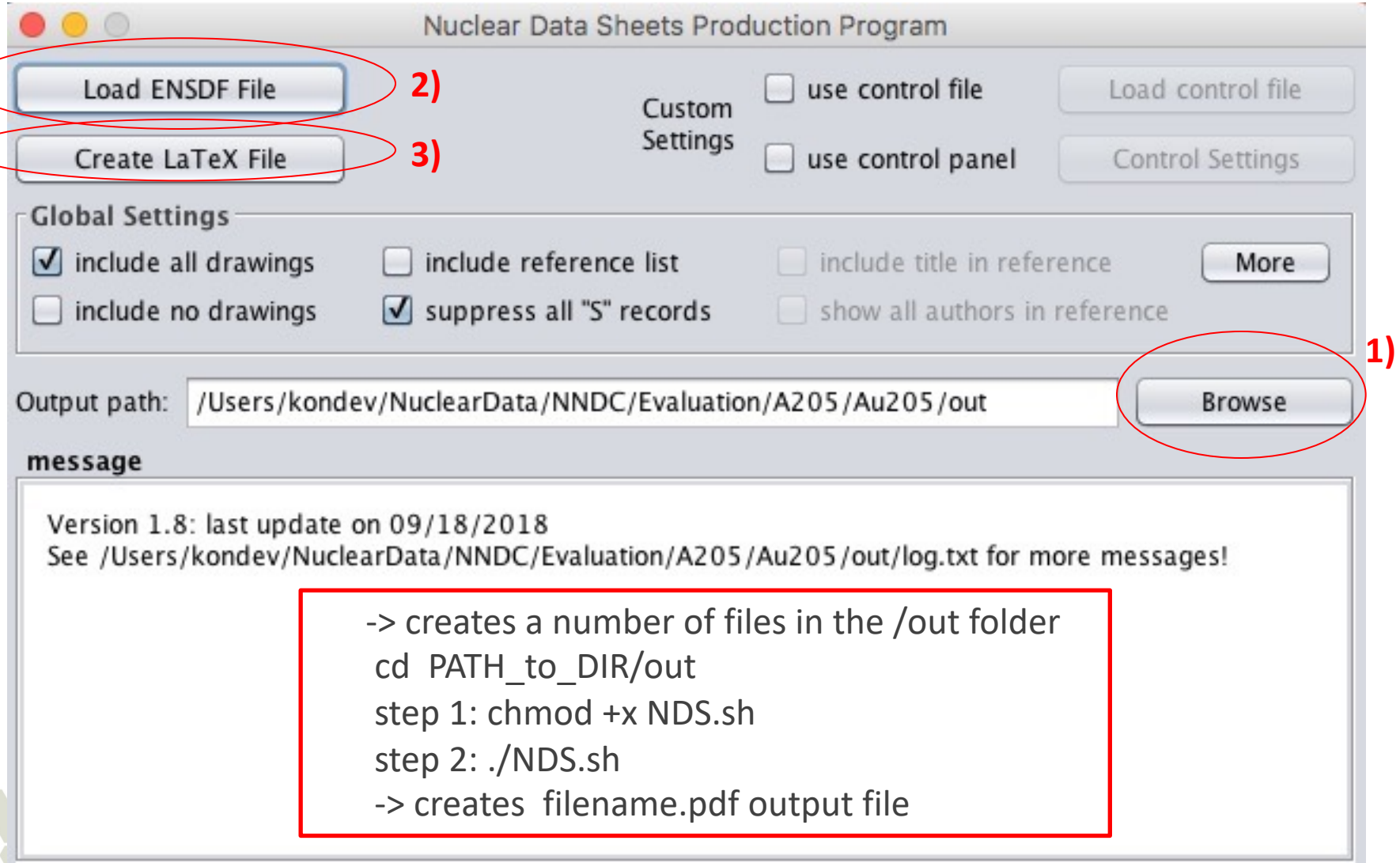

McMaster-MSU-JAVA-NDS

how to run it (linux & MacOSX): **java –jar program_name.jar** &



filename.pdf

Adopted Levels, Gammas

Q(β^-)=−796 *12*; S(n)=7059 *29*; S(p)=4790 *6*; Q(α)=1667 *6* 2021Wa16

^{200}Tl Levels

Cross Reference (XREF) Flags

A ^{200}Tl IT decay
B ^{200}Pb ε decay
C ^{198}Pt(^{6}Li,4nγ)
D ^{198}Pt(^{7}Li,5nγ)
E ^{197}Au(^{207}Pb,Xγ)

E(level)†	J$^\pi$	$T_{1/2}$	XREF	Comments
0	2$^-$	26.1 h *1*	ABCDE	%ε+%β^+=100 μ=0.04 *1* (1976Ek03,2019StZV) J$^\pi$: Atomic beam (1958Ma21); μ. $T_{1/2}$: From 1962Ja10; Others: 26.1 h *4* (1957He43) and 27 h *1* (1954Mi16). μ: Atomic beam magnetic resonance technique. Negative sign is favored by theory. Others: $\mu\leq$0.15 (1961Hu04,1961Hu08). configuration: Probable a mixture of $\pi(s_{1/2}^{-1})\otimes\nu(p_{3/2}^{-1})$ and $\pi(s_{1/2}^{-1})\otimes\nu(f_{5/2}^{-1})$.
147.634 *21*	0$^-$	7.10 ns *15*	B	J$^\pi$: 147.63γ E2 to 2$^-$; log *ft* in ^{200}Pb ε decay favors J=0,1. $T_{1/2}$: From 1959Jo21; Others: 7.3 ns *3* (1960Ba05) and 8 ns *2* (1957As64). All values are from ^{200}Pb ε decay. configuration: Dominant $\pi(s_{1/2}^{-1})\otimes\nu(p_{1/2}^{-1})$.
257.183 *22*	1$^-$		B	J$^\pi$: 109.54γ M1 to 0$^-$, 257.19γ M1+E2 to 2$^-$. configuration: Probable dominant $\pi(s_{1/2}^{-1})\otimes\nu(p_{1/2}^{-1})$.
289.24 *5*	(2)$^-$		B	J$^\pi$: 289.24γ M1 to 2$^-$; log *ft* in ^{200}Pb ε decay favors J=2. configuration: Probable dominant $\pi(s_{1/2}^{-1})\otimes\nu(p_{3/2}^{-1})$.
289.92 *3*	1$^-$		B	J$^\pi$: 142.28γ M1 to 0$^-$.
323.70 *17*	(3)$^-$		A CD	J$^\pi$: 323.7γ to 2$^-$; 217.2γ M1+E2 from 4$^-$; the absence of feeding from the 5$^+$ level at 762 keV would argue against J=4.
450.56 *4*	1$^-$		B	J$^\pi$: 302.93γ M1 to 0$^-$.
525.54 *3*	1$^-$		B	J$^\pi$: 235.62γ M1 to 1$^-$; 377.92γ to 0$^-$; log *ft* in ^{200}Pb ε decay favors J=1.
540.90 *17*	4$^-$		A CDE	J$^\pi$: 540.9γ E2 to 2$^-$; absence of ε feeding in ^{200}Pb ε decay favors J>2. configuration: Probable $\pi(d_{3/2}^{-1})\otimes\nu(f_{5/2}^{-1})$.
605.45 *4*	1$^-$		B	J$^\pi$: 605.44γ M1 to 2$^-$; 457.80γ to 0$^-$.
753.62 *24*	7$^+$	33.8 ms *18*	A CDE	%IT=100 J$^\pi$: 212.7γ E3 to 4$^-$. $T_{1/2}$: Weighted average of 34.1 ms 10 (1963De38), 33 ms 2 (1967Co20) and 37 ms 4 (1963Di10). configuration: Probably a mixture of $\pi(s_{1/2}^{-1})\otimes\nu(i_{13/2}^{-1})$ and $\pi(d_{3/2}^{-1})\otimes\nu(i_{13/2}^{-1})$.

what you need?

--- 8G RAM memory for running the program smoothly for large ENSDF mass-chain files. If RAM is less than 8G, code will be quite slow, for example about 2-3 minutes with 8GB, 10 min with 6 GB, and >15 min for 4 GB.

--- latest version of Java:

JRE 8 or above, which can be downloaded at http://java.com/en/download/

--- LaTeX compiler:

for Windows, **MiKTEX,** free to download at http://miktex.org/download

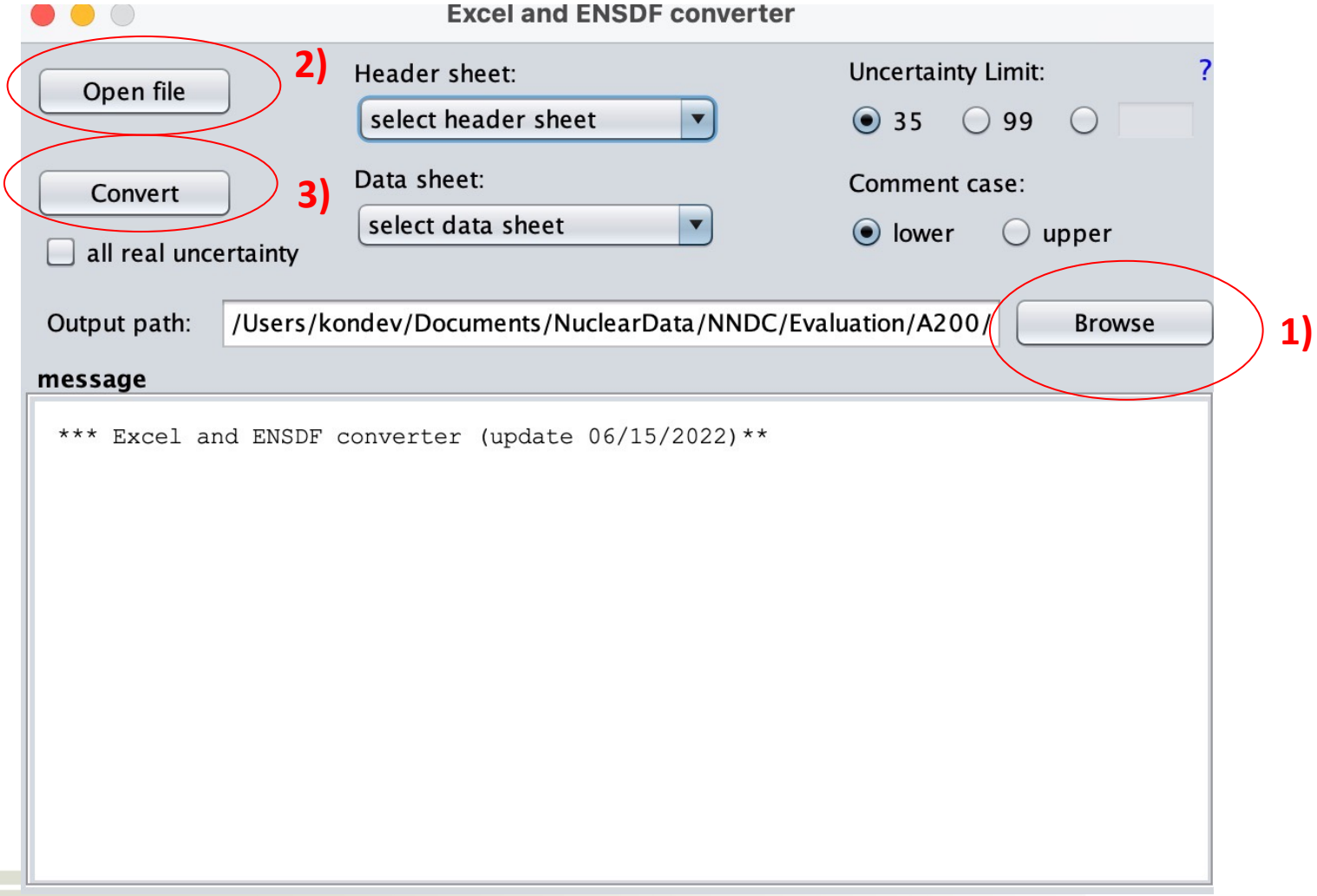
Download MiKTEX 64-bit (or 32-bit) version appropriate to your computer.

for Linux and MacOS, a LaTex compiler should come with the system.

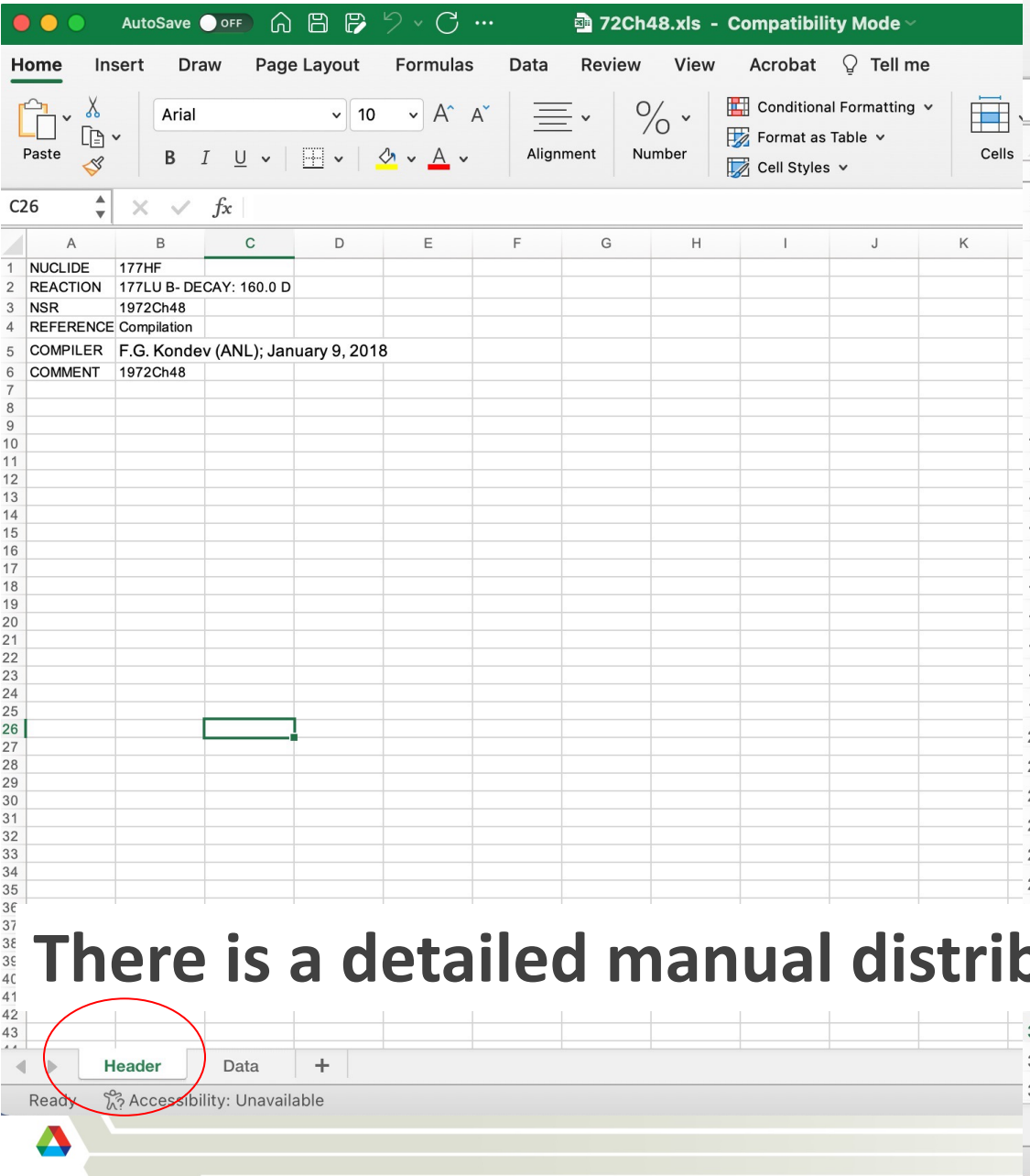
There is a detailed manual distributed with the program

Excel2ENSDF

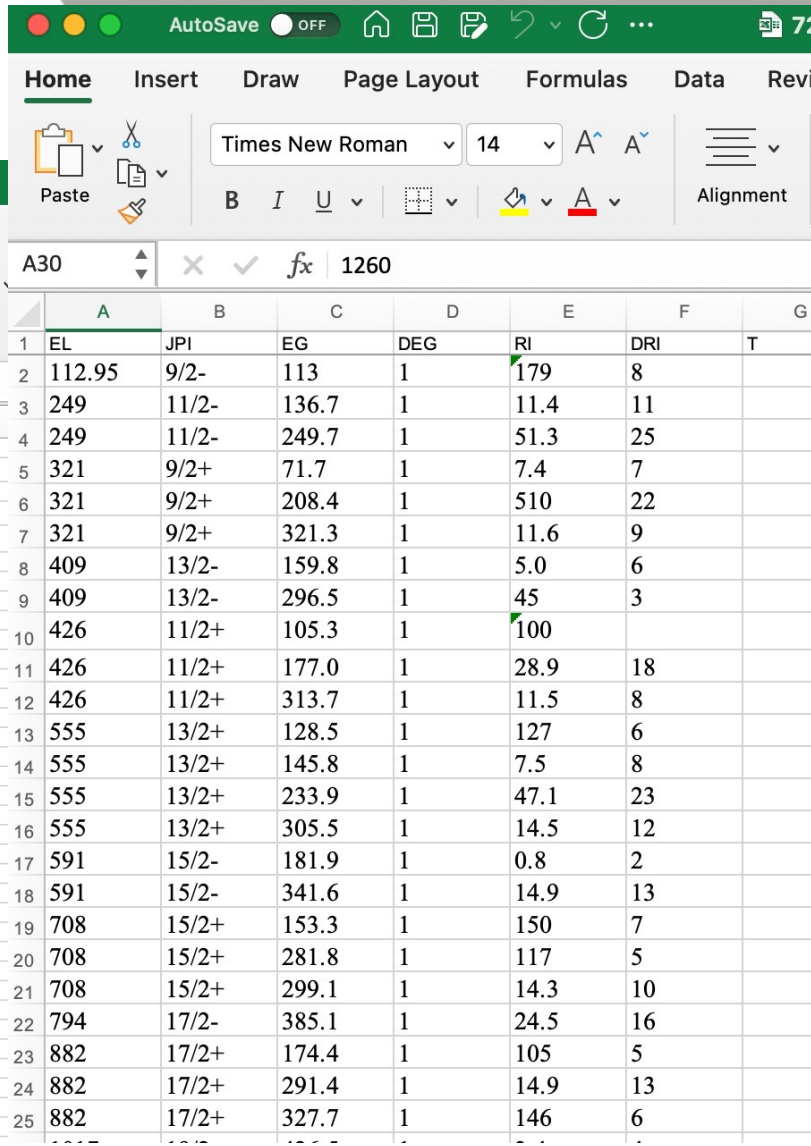
how to run it (linux & MacOSX): **java –jar program_name.jar** & needs an xls file with a Header and Data sheets



filename.xls



	A	B	C	D	E	F	G	H	I	J	K
1	NUCLIDE	177HF									
2	REACTION	177LU B- DECAY: 160.0 D									
3	NSR	1972Ch48									
4	REFERENCE	Compilation									
5	COMPILER	F.G. Kondev (ANL); January 9, 2018									
6	COMMENT	1972Ch48									



	A	B	C	D	E	F	G
1	EL	JPI	EG	DEG	RI	DRI	T
2	112.95	9/2-	113	1	179	8	
3	249	11/2-	136.7	1	11.4	11	
4	249	11/2-	249.7	1	51.3	25	
5	321	9/2+	71.7	1	7.4	7	
6	321	9/2+	208.4	1	510	22	
7	321	9/2+	321.3	1	11.6	9	
8	409	13/2-	159.8	1	5.0	6	
9	409	13/2-	296.5	1	45	3	
10	426	11/2+	105.3	1	100		
11	426	11/2+	177.0	1	28.9	18	
12	426	11/2+	313.7	1	11.5	8	
13	555	13/2+	128.5	1	127	6	
14	555	13/2+	145.8	1	7.5	8	
15	555	13/2+	233.9	1	47.1	23	
16	555	13/2+	305.5	1	14.5	12	
17	591	15/2-	181.9	1	0.8	2	
18	591	15/2-	341.6	1	14.9	13	
19	708	15/2+	153.3	1	150	7	
20	708	15/2+	281.8	1	117	5	
21	708	15/2+	299.1	1	14.3	10	
22	794	17/2-	385.1	1	24.5	16	
23	882	17/2+	174.4	1	105	5	
24	882	17/2+	291.4	1	14.9	13	
25	882	17/2+	327.7	1	146	6	
30	1260	21/2-	465.9	1	19.4	13	
31	1301	21/2+	214.4	1	55	3	
32	1301	21/2+	283.4	1	4.3	6	

There is a detailed manual distributed with the program

avetools

developed by T. Kibedi (ANU)

VisualAveragingLibrary (avelib)

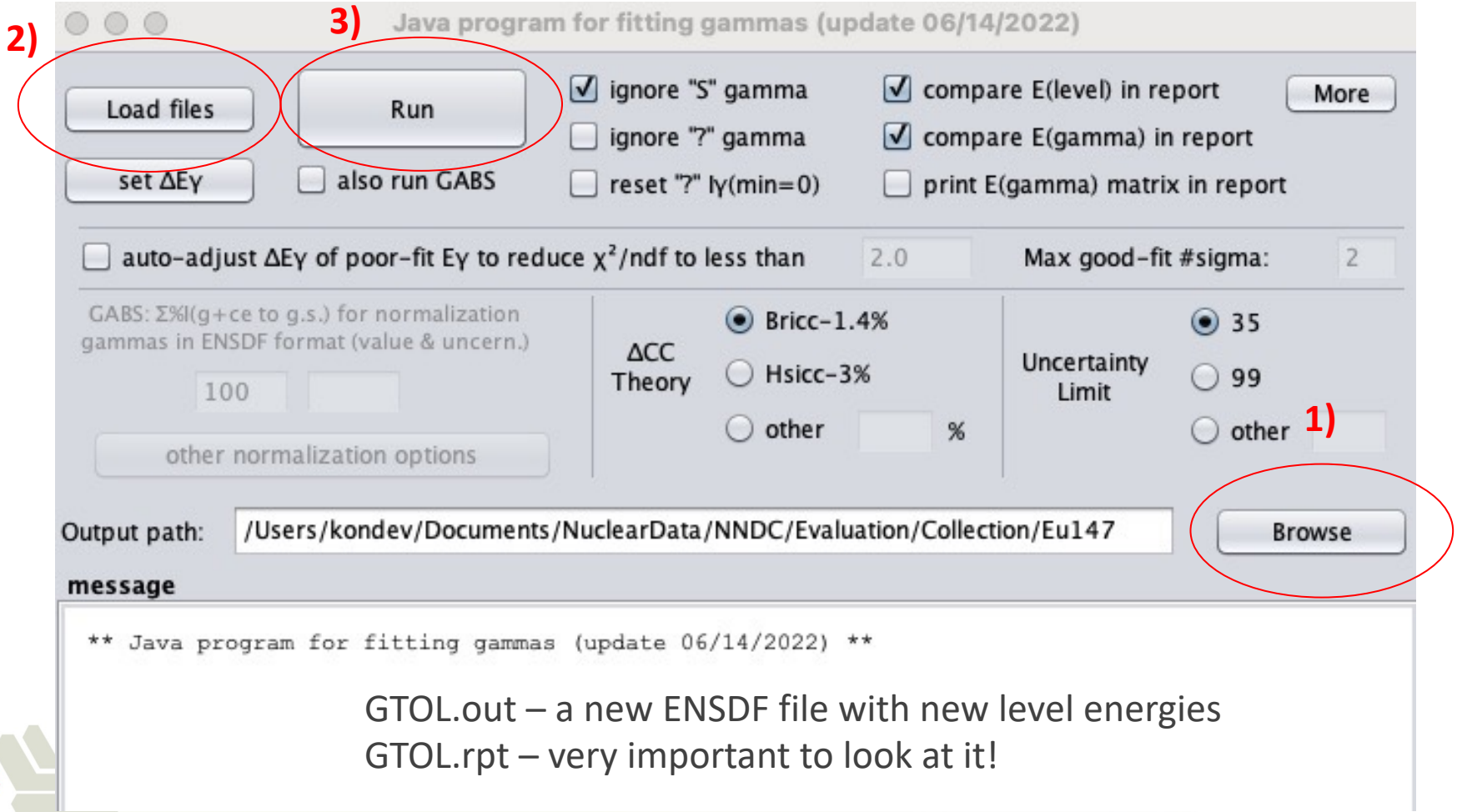
developed by M. Birch & B. Singh (McMaster U)

ENSDF Analysis Codes

GLSC

how to run it (linux & MacOSX): **java –jar program_name.jar** &

- determines level energies using a LSQ fit to gamma-ray energies
- determines total gamma-ray intensity balances at each level (decay data sets)
- + many other useful things …



GTOL.out – a new ENSDF file with new level energies
GTOL.rpt – very important to look at it!

α, β (EC) and γ-ray transition probabilities

ALPHAD (AlphaHF – J. Chen/MSU)
LOGFT (BetaShape – X. Mougeot/CEA)
RULER (JAVA-RULER – J. Chen/MSU)

the new codes are in test mode or to be adopted by NSDD

how to run it (linux & MacOSX): program_name filename.ens
output files:
program_name.rpt (report file)
program_name.out (ENSDF-formatted file)

ENSDF Analysis Codes

BrICC
BrICCMixing
GABS

will be covered by T. Kibedi (ANU)

What about uncertainties?

$Q = f[x_i(\Delta x_i)]$, i=1,2,...,n

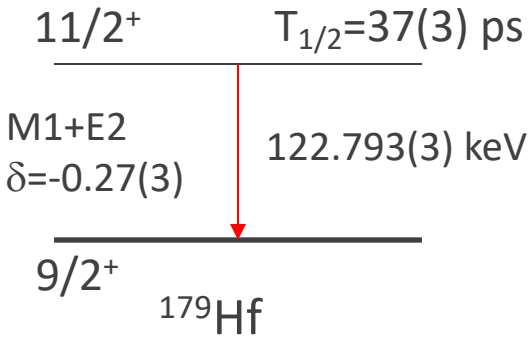
$$\Delta Q = \Delta f = \sqrt{\sum \frac{\partial f}{\partial x_i}^2 \Delta x_i^2}$$

http://pythonhosted.org/uncertainties/

uncertainties

```
>>> x = ufloat(0.20, 0.01)  # x = 0.20+/-0.01
```

```
>>> from uncertainties import ufloat_fromstr
>>> x = ufloat_fromstr("0.20+/-0.01")
>>> x = ufloat_fromstr("(2+/-0.1)e-01")  # Factored exponent
>>> x = ufloat_fromstr("0.20(1)")  # Short-hand notation
>>> x = ufloat_fromstr("20(1)e-2")  # Exponent notation
>>> x = ufloat_fromstr(u"0.20±0.01")  # Pretty-print form
>>> x = ufloat_fromstr("0.20")  # Automatic uncertainty of +/-1 on last digit
```



$$B(E2)\,[\mathrm{W.u.}] = \frac{9.527\times10^{6}\times BR}{E_{\gamma}^{5}\times A^{4/3}\times T_{1/2}\times(1+\alpha_T)} \times \left(\frac{\delta^2}{1+\delta^2}\right)$$

> python

from uncertainties import *

from uncertainties.umath import *

Eg=ufloat(122.793,0.003) : gamma-ray energy (E_γ) in keV

aT=ufloat(2.18,0.04) : total conversion electron coefficient (α_T)

T=ufloat(37e-12,3e-12) : half-life (T1/2) in s

MR=ufloat(-0.27,0.03) : M1/E2 mixing ration (δ): δ^2=I(E2)/I(M1)]

A=179.

BR=1.0

```
BE2=9.527e6*pow(MR,2)/(pow(Eg,5)*pow(A,4/3)*T*(1+aT)*(1+pow(MR,2)))
BE2=195.3545421570429+/-43.52168547254121
```

B(E2)=195(44) [W.u.]