

1. The FRIB mass explorer
2. The FRIB mass excess file locations within the LISE⁺⁺ package
3. How to load a LISE⁺⁺ mass excess file
4. Where and how are mass tables used in the code?
5. Plotting mass-related isotope characteristics
6. How to update the LISE⁺⁺ table of nuclides with a new mass table
7. How to create a LISE⁺⁺ mass excess file from an FRIB mass table
8. LISE⁺⁺ “stability” plots with different mass tables

Acknowledgement to Dr. Erik Olsen for help in porting the FRIB mass tables to LISE⁺⁺

<http://massexplorer.frib.msu.edu/>



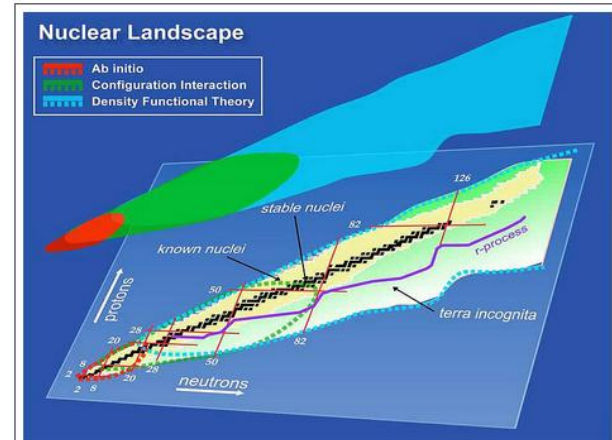
Contact
DFT Mass Tables
People
Plotting Tools
Useful Links

References for the mass tables:

- Erler et al., *Nature* **486**, 509 (2012).
- <http://massexplorer.frib.msu.edu>.

References for the individual energy density functionals:

- **SKM***: Bartel et al., *Nucl. Phys. A* **386**, 79 (1982).
- **SKP**: Dobaczewski et al., *Nucl. Phys. A* **422**, 103 (1984).
- **SLy4**: Chabanat et al., *Nucl. Phys. A* **635**, 231 (1998).
- **SV-min**: Klupfel et al., *Phys. Rev. C* **79**, 034310 (2009).
- **UNEDF0**: Kortelainen et al., *Phys. Rev. C* **82**, 024313 (2010).
- **UNEDF1**: Kortelainen et al., *Phys. Rev. C* **85**, 024304 (2012).



An understanding of the properties of atomic nuclei is crucial for a complete nuclear theory, present and future energy and defense applications, and an understanding of both element formation and the properties of stars. The long term vision of nuclear theory is to arrive at a comprehensive and unified description of nuclei and their reactions grounded in the fundamental interactions between the constituent protons and neutrons. The new and exciting frontier in nuclear theory lies in the description of exotic, short-lived nuclei that have unusually large (or small) neutron-to-proton ratios. This website contains results from large-scale Density Functional Theory calculations of ground state properties of even-even nuclei throughout the nuclear landscape.

See Erler et al., *Nature* **486**, 509 (2012) for details.

LISE\bin\FRIB_mass*.lme

Name	Ext
[..]	
SKMS	.lme
SKP	.lme
SLY4	.lme
SV-MIN	.lme
UNEDF0	.lme
UNEDF1	.lme

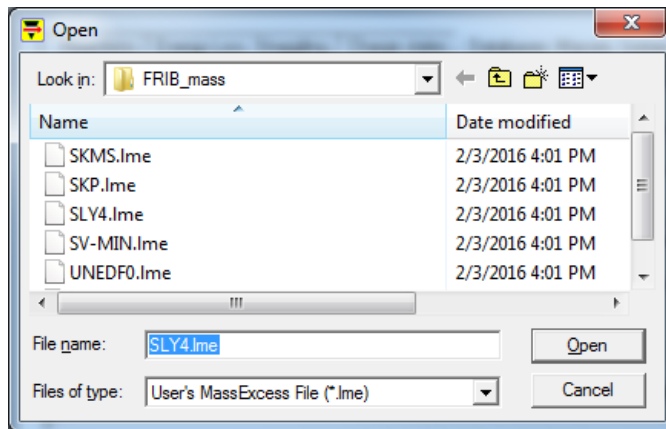
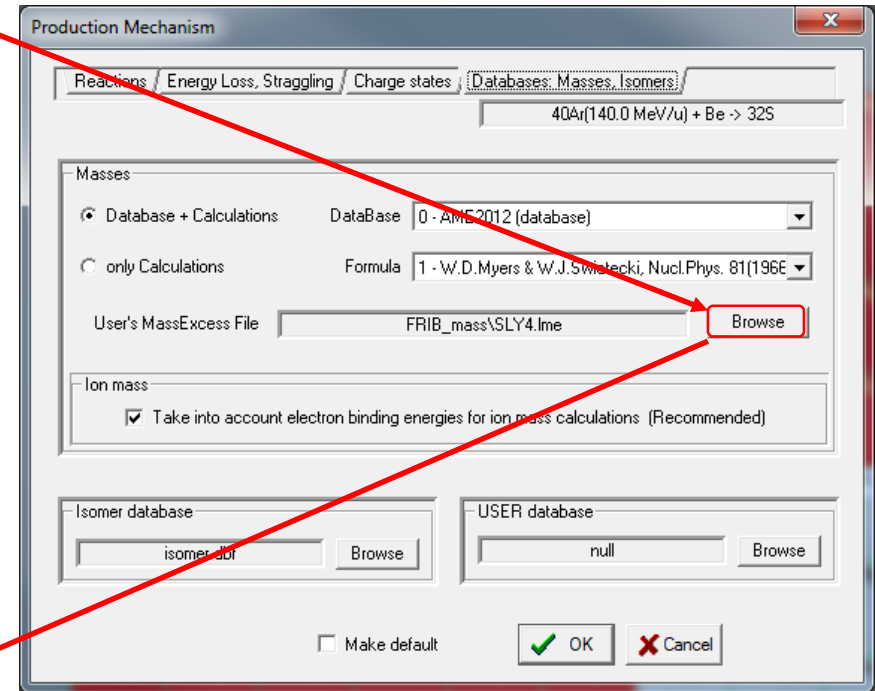
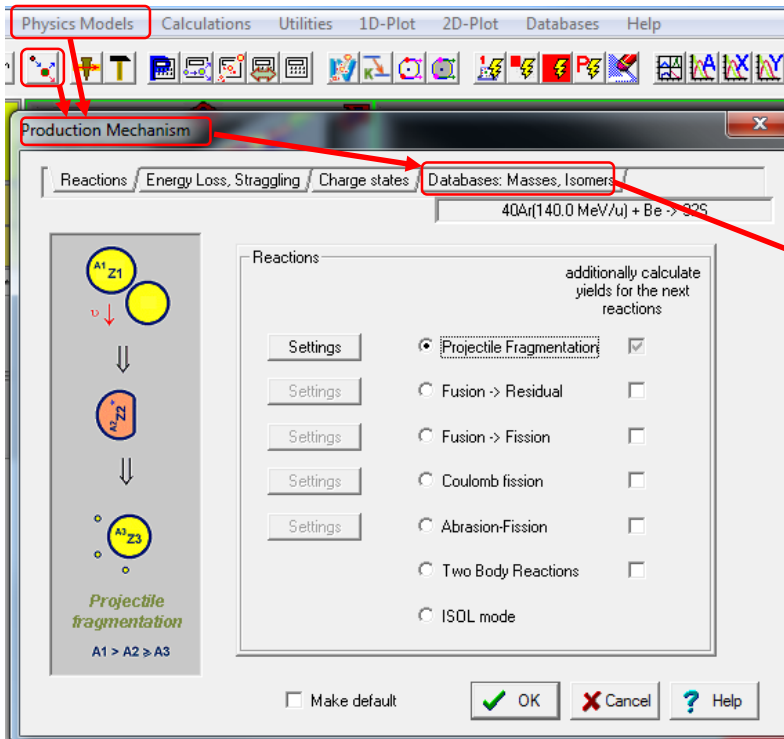
“lme” - LISE Mass Excess file

```

File Edit Options Help
# FRIB mass tables ==> http://massexplorer.frib.msu.edu/
1000 7.289000e+00 0.000000e+00
1001 1.313570e+01 0.000000e+00
1002 1.494980e+01 0.000000e+00
1003 2.590000e+01 1.000000e-01
1004 3.289000e+01 1.000000e-01
1005 4.186000e+01 2.600000e-01
1006 4.914000e+01 1.010000e+00
2001 1.493120e+01 0.000000e+00
2002 7.011355e-01
2003 1.008743e+01
2004 9.674855e+00
2005 2.009544e+01
3002 1.059513e+01
3003 1.586838e+01
3004 1.182695e+01
4002 1.088463e+01
4003 1.251216e+01
4004 5.309200e+00
4005 9.153321e+00
4006 6.156035e+00
4007 1.435609e+01
4008 1.632163e+01
4009 2.659427e+01
4010 3.188990e+01
4011 4.210916e+01
4012 4.796342e+01
4013 5.815453e+01
5004 1.048890e+01
5005 1.103095e+01
5006 5.026000e+00
  
```

General header for all FRIB lme files

Data obtained from the FRIB mass table

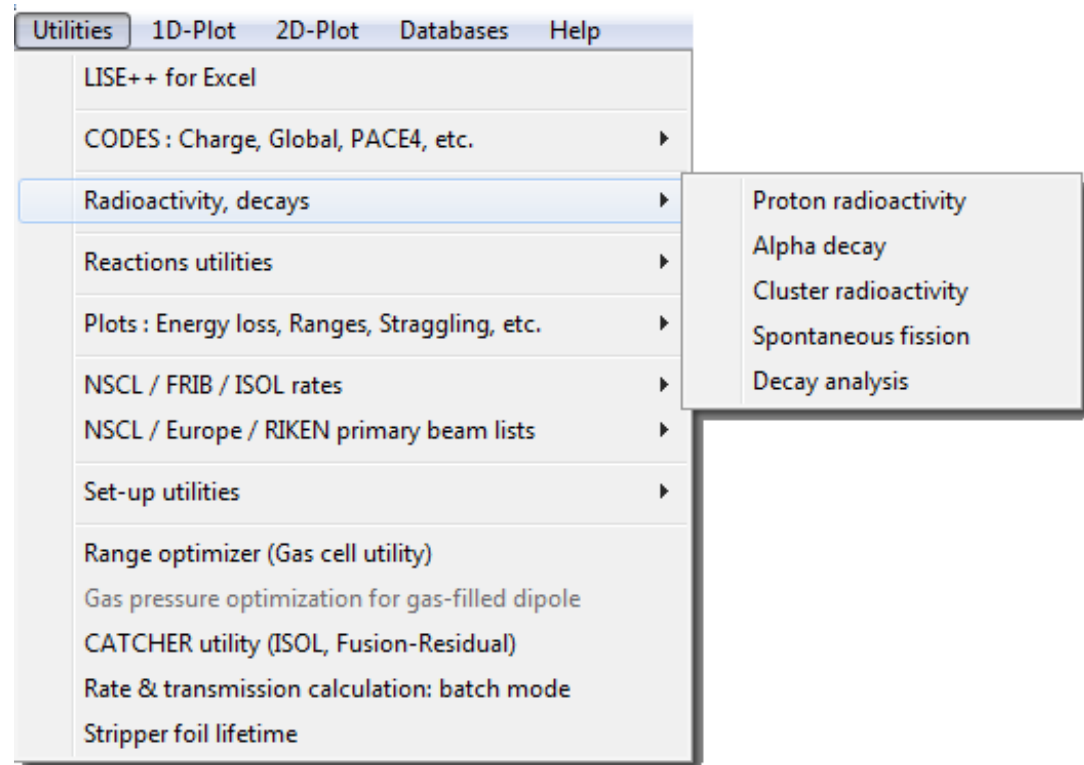


1. Transmission (ion mass) calculations

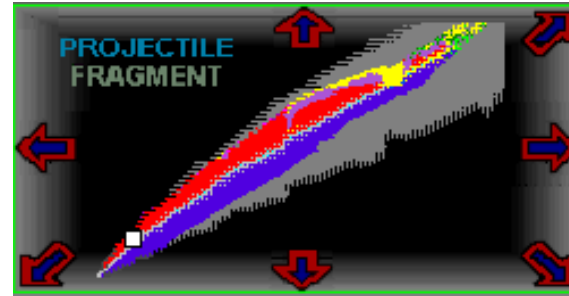
2. Cross section (de-excitation channel) calculations

see for example Fig.11 in PRC 87, 054612 (2013)

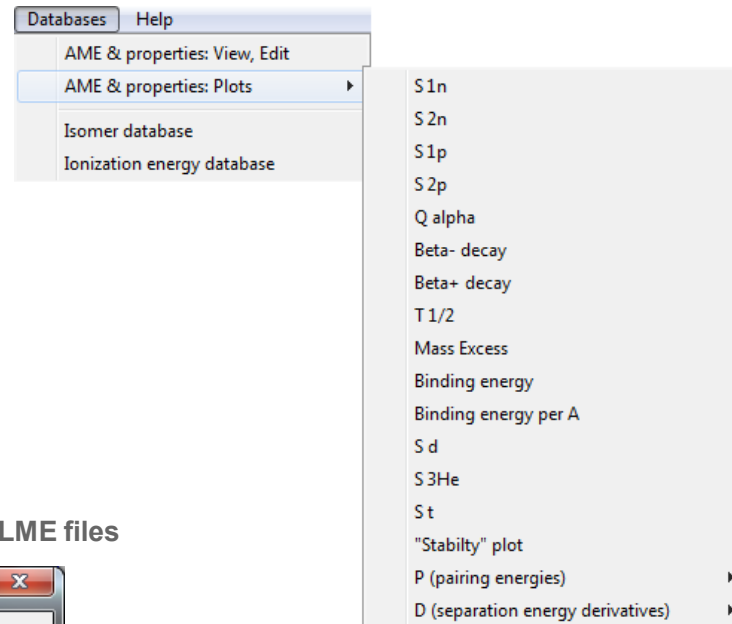
3. Radioactivity utilities



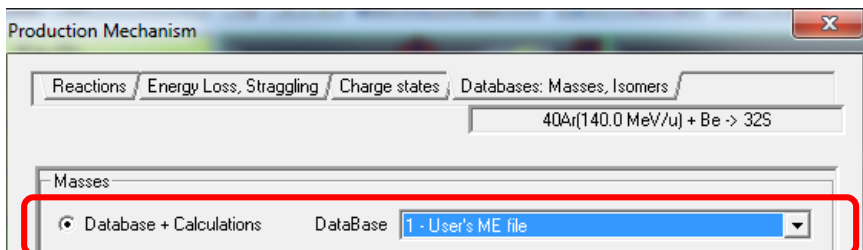
4. Generate the LISE++ table of nuclides



5. Plotting mass-related isotope characteristics



Note: Items 1-4 require to set "1-User's ME file" in order to use LME files



Databases Help

- AME & properties: View, Edit
- AME & properties: Plots
- Isomer database
- Ionization energy database

- S1n
- S2n
- S1p
- S2p
- Q alpha
- Beta- decay
- Beta+ decay
- T1/2
- Mass Excess
- Binding energy
- Binding energy per A
- S d
- S3He
- S t
- "Stability" plot
- P (pairing energies)
- D (separation energy derivatives)

Choose a Plot Type

Select a data set to plot

plot one data set Show extrapolated values based on selected LDM for missing data in databases
 difference between data sets

Database: 1 - User's ME file (SLY4)
 Database: 0 - AME2012 (database)
 Database: 1 - User's ME file (SLY4)
 Calculation: 0 - Liquid Drop Model (regular)
 Calculation: 1 - W.D.Myers & W.J.Swiatecki, Nucl.Phys. 81(1966)1 **or**
 Calculation: 2 - LDM#1 + shell corrections (B.T.)
 All methods

ONE-dimensional Isotopes, Z=const Z (protons)
 TWO-dimensional Isobars, A=const A (nucleons)
 Isotones, N=const N (neutrons)
 Isospin, N-Z=const N-Z (isospin)
 Isospin, N-ZZ=const N-ZZ

Zmin = 20
Zmax = 20

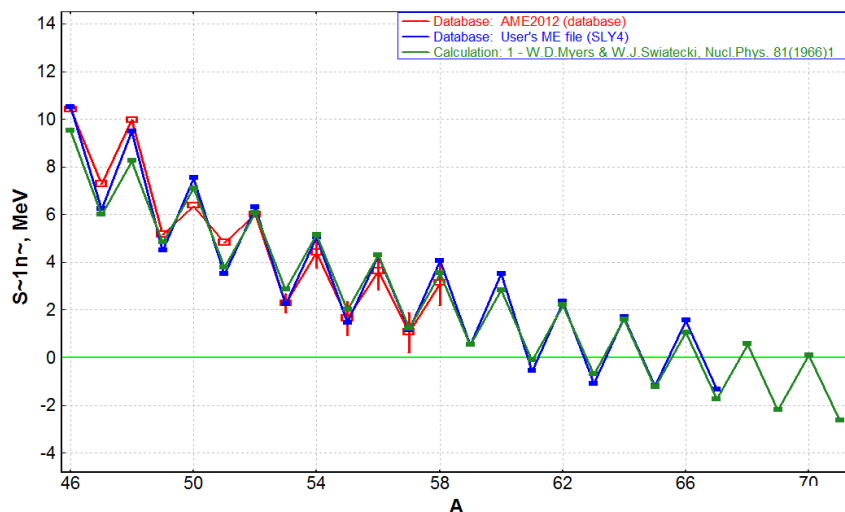
2D: Color scale board based on

Internal database values or calculations
 External source (iso & isolist files)

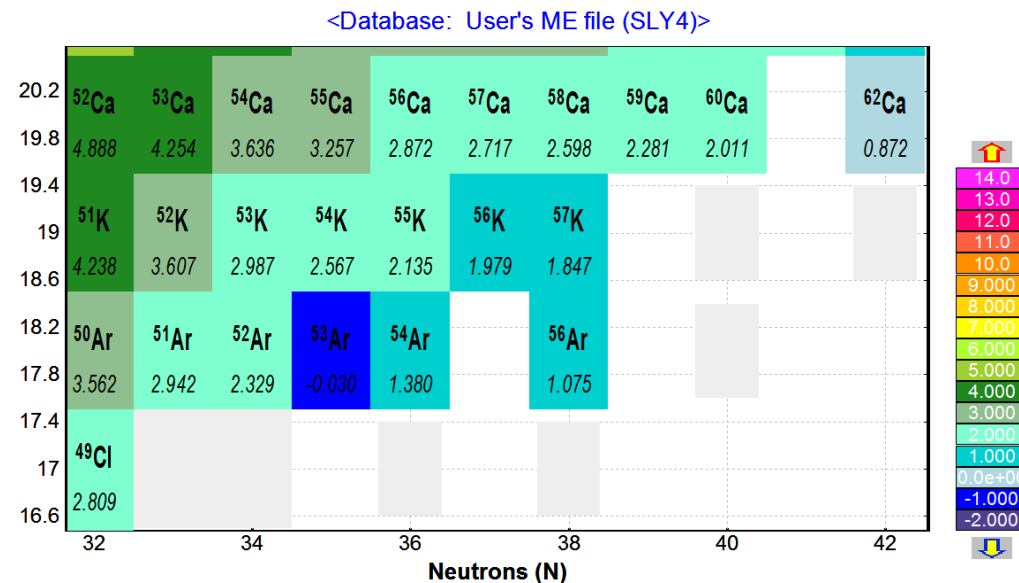
Decay mode filter: All modes

All Odd Even

S_{1n}
<All methods>
Z=20



- S1n
- S2n
- S1p
- S2p
- Q alpha
- Beta- decay
- Beta+ decay
- T1/2
- Mass Excess
- Binding energy
- Binding energy per A
- S d
- S3He
- S t
- "Stability" plot
- P (pairing energies)
- D (separation energy derivative)



Choose a Plot Type

Select a data set to plot

plot one data set Show extrapolated values based on selected LDM for missing data in databases

difference between data sets

Calculation: 2 - LDM#1 + shell corrections (O.T.)

Database: 1 - User's ME file (SLY4)

Calculation: 1 - W.D. Myers & W.J. Swiatecki, Nucl.Phys. 81(1966)1

Calculation: 2 - LDM#1 + shell corrections (O.T.)

ONE-dimensional Isotopes, Z=const Z (protons)

TWO-dimensional Isobars, A=const A (nucleons)

Isotopes, N=const N (neutrons)

Isospin, N-Z=const N-Z (isospin)

Isospin, N-ZZ=const N-ZZ

Nmin = 0

Nmax = 200

2D: Color scale board based on

Internal database values or calculations

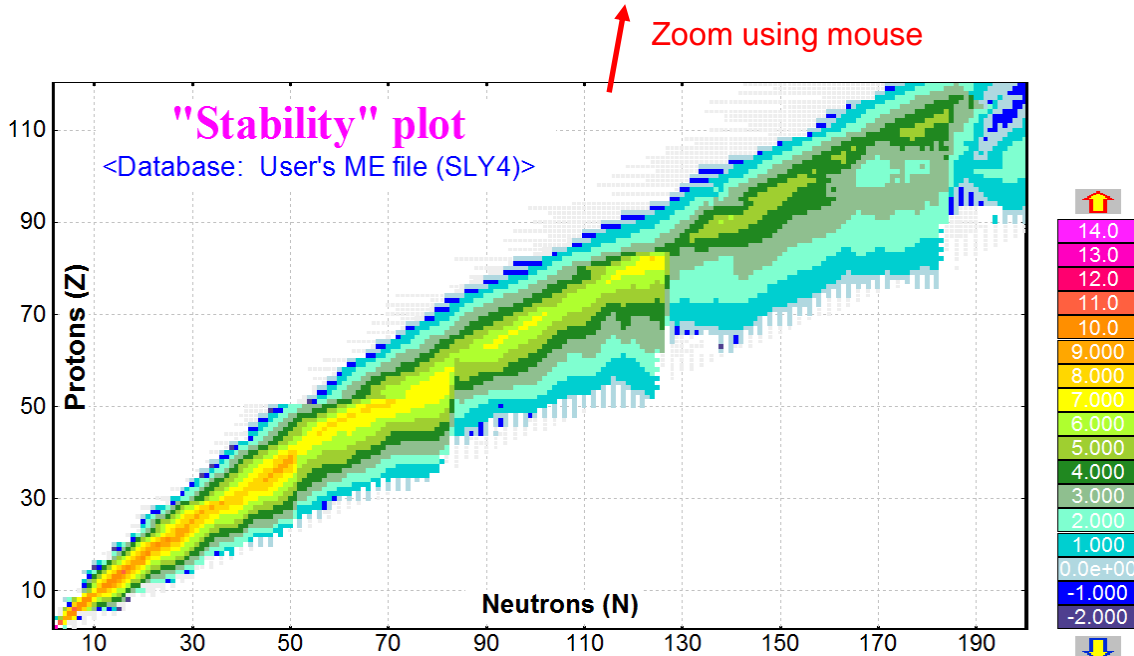
External source (iso & isolist files)

Decay mode filter: All modes

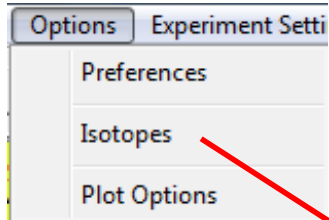
NZ chart

All Odd Even

OK Cancel



The table of nuclides defines isotopes to be used in transmission calculations and shown in the resulting 2D-plots



Steps to generate the table

The 'Isotopes' dialog box is shown with the following settings and annotations:

- Element:** Sulfur (S, Z=16)
- Table of Nuclides:** Buttons for Z and N adjustments.
- Masses from:** User's ME file [SLY4] + LDM#1 (highlighted with a red box and a red arrow pointing to it from the text 'Pay attention on mass model !!').
- "Unknown" decay mode:**
 - Option 1: Transform "Unknown" to "Doesn't exist" (indicated by a red '1' and a blue arrow).
 - Option 2: Search particle bound isotopes (set as "Doesn't exist") and mark them as "Unknown" (indicated by a red '2' and a blue arrow).
- Options for search "UnKnown" isotopes:**
 - Include proton emitters if their halflives exceed the next threshold
 - T_{1/2} threshold = 1.00e-09 sec
 - see The Proton Radioactivity dialog (menu "Utilities") to get details
- Colors: Fonts and background:**
 - Font : Element: change
 - Font : Rates: change
 - Background: change
- Decay mode analysis:** Make it default
- Buttons:** Ok, Quit

Utilities | 1D-Plot | 2D-Plot | Databases | Help

- LISE++ for Excel
- CODES : Charge, Global, PACE4, etc. ▶
- Radioactivity, decays ▶
- Reactions utilities ▶
- Plots : Energy loss, Ranges, Stragglings, etc. ▶
- NSCL / FRIB / ISOL rates ▶
- NSCL / Europe / RIKEN primary beam lists ▶
- Set-up utilities ▶**
- Range optimizer (Gas cell utility)
- Gas pressure optimization for gas-filled dipole
- CATCHER utility (ISOL, Fusion-Residual)
- Rate & transmission calculation: batch mode
- Stripper foil lifetime

- Calculation of Angle on the LISE3 target
- MSP-144 utility
- Twinsol (solenoid) utility
- FRIB mass table converter to LISE++ lme file**

FRIB mass table converter to LISE++ lme file

Open file | View file | Clear

SKP.fmass

Number of rows

Data	Comments	Total
2076	1	2077

Convert | Cancel | FRIB mass link

Note

The FRIB mass file is in ASCII format.
Comment string begin with "!" or "!"

The Columns can be separated by a Space, a Comma or a Tabulation. User can put comments also at the end of data line.

There are FIVE columns: "Z", "N", "HFB_Energy_LN", "Pairing_gap_P", "Pairing_gap_N",
where Z is atomic number, N is number of neutrons,
Pairing_energy_P and Pairing_energy_N are proton and neutron pairing gaps (MeV)

There are only even-even isotopes. LISE++ calculates odd values

SKP.lme

i LISE++ mass excess file (lme) has been successefully created from the FRIB mass table!

OK

- All results shown here (except for HFB_energy) were calculated with Lipkin-Nogami.

- HFB_energy_LN should be considered as the calculated ground-state energy for a particular nucleus.

SkM* (.dat file)

SkM* (Excel file)

SkP (.dat file)

SkP (Excel file)

	A	B	C	D	E	F	G	H	I	J	K	L
LBL	Z	N	A	Kinetic_P	Kinetic_N	Kinetic_tc	Spin-orbit	Coulomb	Coulomb	Pairing_er	Pairing_er	HFB
1	HE	2	2	4	26.09783	26.34019	52.43801	-1.48917	1.379825	-0.58694	-6.2486	-6.32941
2	HE	2	4	6	25.31138	51.91349	77.22487	-3.17426	1.372689	-0.58427	-3.76806	-5.83494
3	HE	2	6	8	24.36406	74.9851	99.34916	-3.54678	1.34226	-0.57169	-2.91611	-5.95368
4	BE	4	2	6	50.33793	25.54716	75.88509	-3.01015	4.620827	-1.23983	-5.61533	-3.97994
5	BE	4	4	8	56.21231	57.00721	113.2195	-6.57324	4.807899	-1.29381	-4.60803	-4.71233
6	BE	4	6	10	56.837	86.60532	143.4423	-7.75717	4.777887	-1.28794	-3.79965	-5.06791
7	BE	4	8	12	55.76331	112.6172	168.3805	-6.62418	4.68743	-1.26543	-3.33107	-4.95453
8	C	6	4	10	83.97169	57.24428	141.216	-7.51225	9.78803	-2.0133	-4.65626	-3.89557
9	C	6	6	12	86.85803	88.75272	175.6108	-9.24611	9.897299	-2.04145	-3.68427	-4.17756
10	C	6	8	14	86.38727	118.4034	204.7907	-7.78804	9.795554	-2.02491	-3.3669	-4.58892
11	C	6	10	16	85.14888	154.5517	239.7006	-9.37585	9.676541	-2.00366	-2.98685	-5.81252
12	C	6	12	18	83.91125	192.0603	275.9716	-12.765	9.574547	-1.98518	-2.53741	-6.87705
13	C	6	14	20	82.68523	224.7899	307.4751	-15.6267	9.475461	-1.96679	-2.21643	-5.88334
14	C	6	16	22	81.07899	252.1156	333.1946	-15.8899	9.3551	-1.9434	-2.06847	-5.07086

Only 5 columns

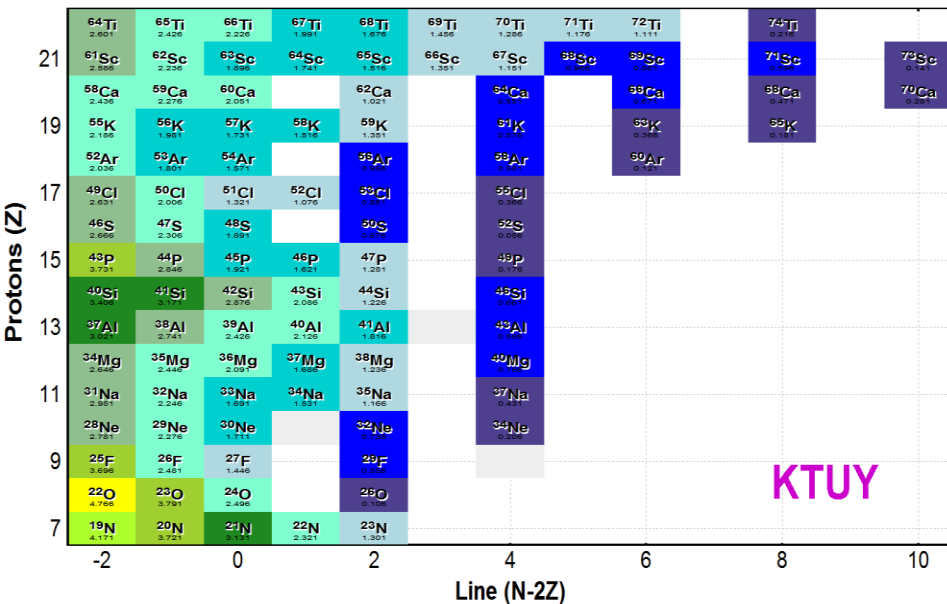
A	B	C	D	E
! Z	N	HFB_Energy_LN	Pairing_gap_P	Pairing_gap_N
2	2	-29.983718	5.597249	5.649244
2	4	-36.159424	5.015006	3.725048
2	6	-37.137744	4.718873	3.265396
4	2	-33.472573	3.600581	5.103016
4	4	-56.070979	3.335483	3.398626
4	6	-70.290303	2.947363	3.324252
4	8	-76.084841	2.659694	2.870412
6	4	-65.861318	3.178553	3.000986
6	6	-92.56665	2.948179	3.110596
6	8	-108.761114	2.792835	2.847825
6	10	-116.246051	2.613274	2.328075
6	12	-121.342826	2.422628	2.279811

Save to ASCII file

LISE++ converter to LME

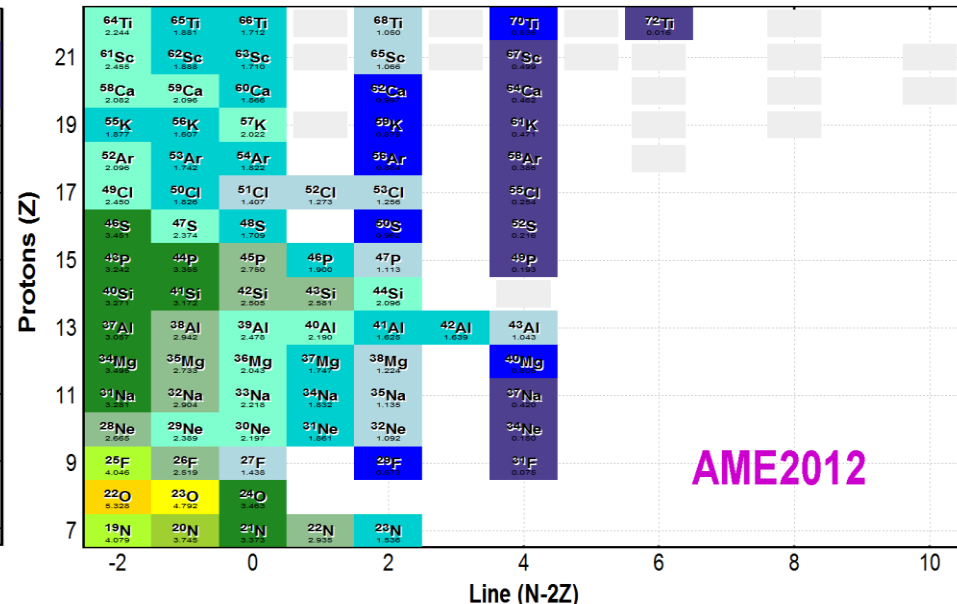
"Stability" plot

<Database: User's ME file (ktuy) + LDM1>



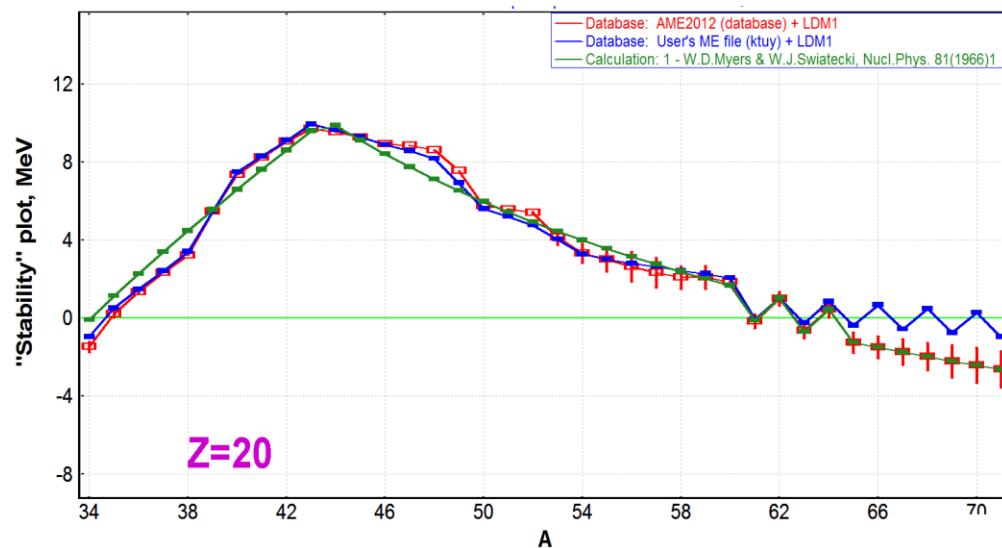
"Stability" plot

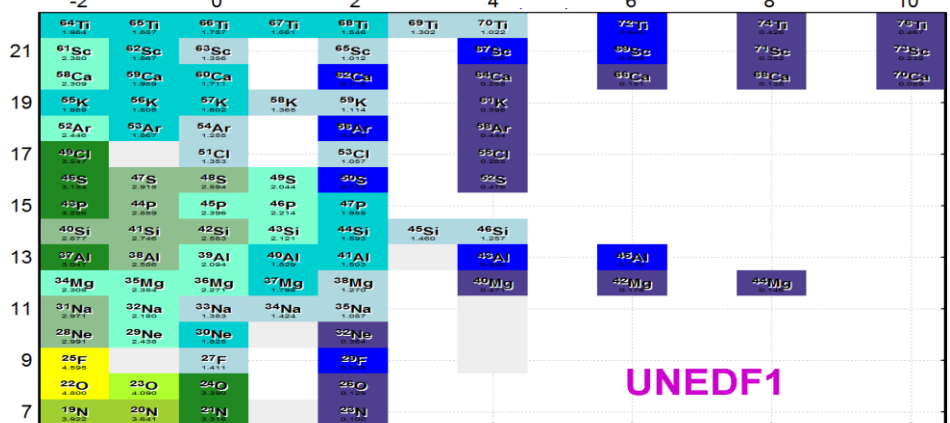
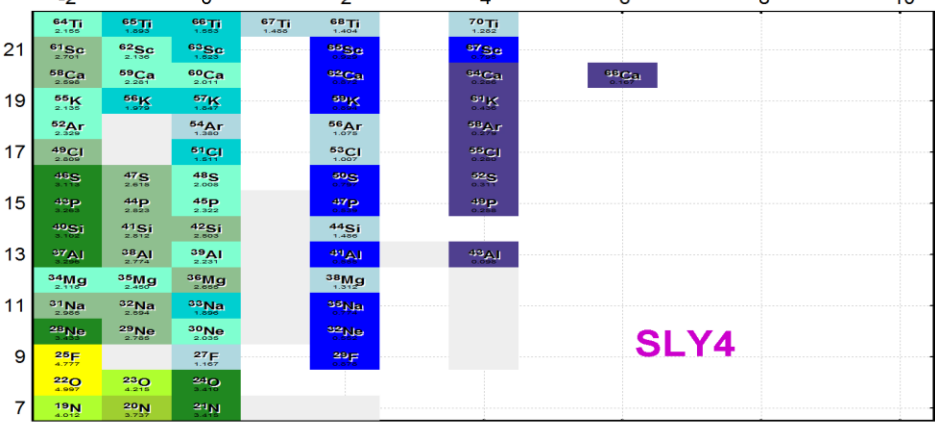
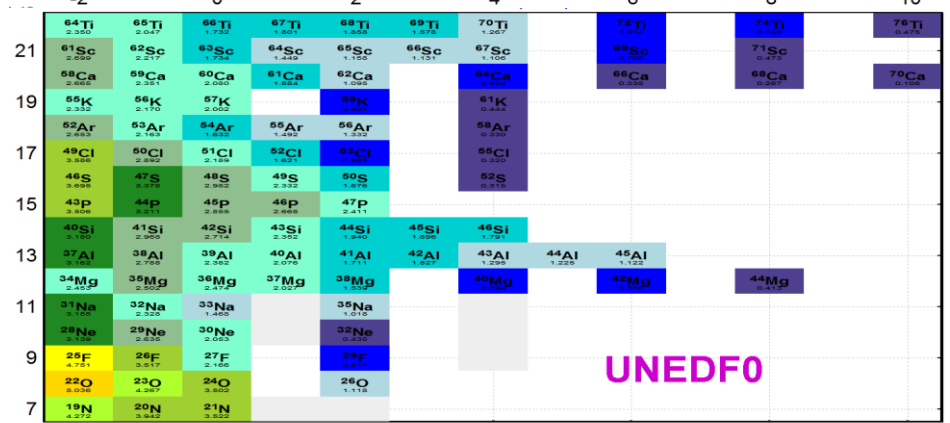
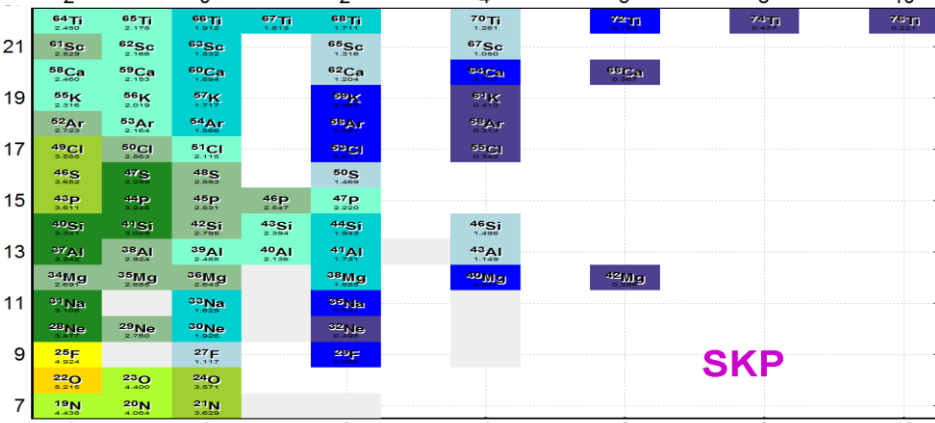
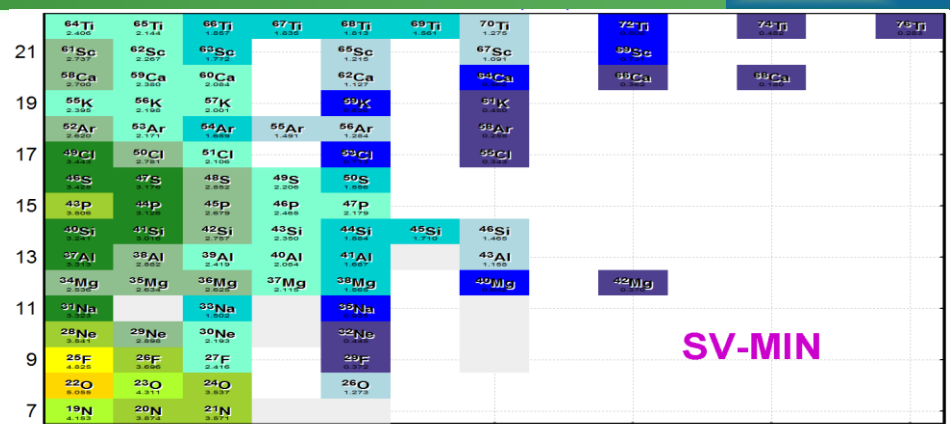
<Database: AME2012 (database) + LDM1>



"Stability" plot information link:

http://lise.nsci.msu.edu/9_8/9_8_some_issue.pdf#page=8





Line (N-Z)

Line (N-Z)

