

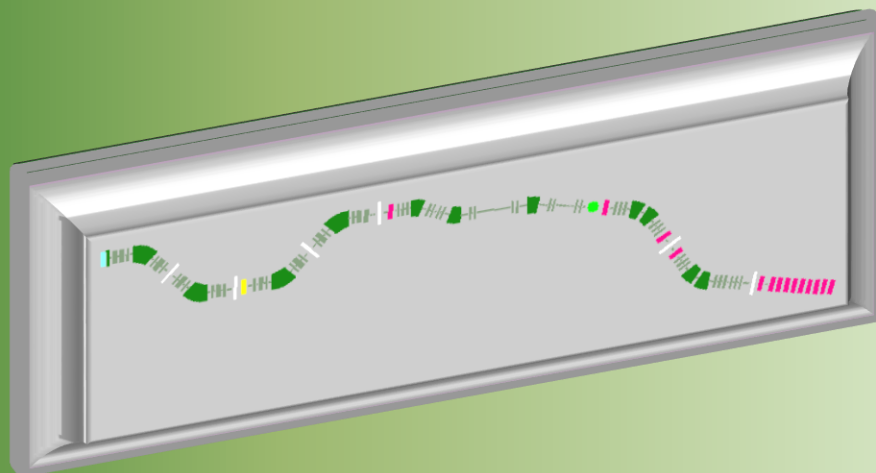
Oleg B. Tarasov
NCSL / MSU, USA

October 2017

Application of modern methods and reaction models for simulation of rare ion beam production


Dubna State University
Dubna State University

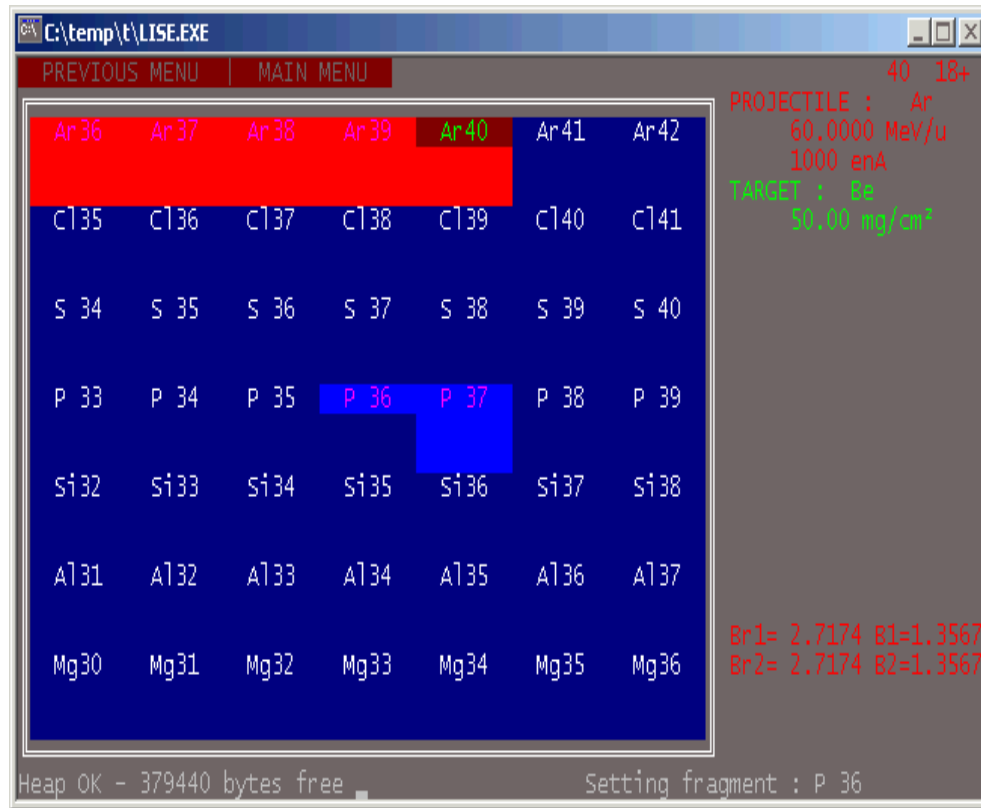
LISE++



LISE++

1. Introduction to production of radioactive ion beams
2. Production Area
3. Separation
4. Identification
5. Production of new isotopes
6. **LISE++: Utilities**
7. Radioactive beam physicist task





LISE REFERENCE MANUAL

Version 2.2 - June 8, 1992

LISE is a DOS-based software running on any IBM compatible PC. It runs under DOS 3.1 and following versions, and only needs 640 kbytes of memory. The speed of the program depends greatly on the CPU type, speed and configuration. The use of a co-processor is greatly recommended: the program uses FFT (Fast Fourier Transform) algorithms which contain extensive floating-point operations. The last version has been developed on a 386-SX at 16 MHz with a co-processor which provides a reasonable speed (about 1 second per transmission calculation).

Name	Ext	Size
[.]		<DIR>
[FILES]		<DIR>
[ISOTOP]		<DIR>
[RANGE]		<DIR>
[RESULTS]		<DIR>
EGAVGA	BGI	5,363
LISE	EXE	383,909
LISE	MAN	64,227
READ	ME	3,684

In 1998 the MS-DOS version with **14** C++ files and less than **10 000** lines of code,

and grew on MS Windows today to **615** files, about **400 000** lines, and size of ~69 MB after Installation.

Almost 593 kBytes

1994-1997
O.T.,
GANIL/Dubna
v.2.3 – 2.9

Corrections, Modifications, Development
(compound target, compensating dipole)

1998
O.T.,
GANIL/Dubna
v.3.1

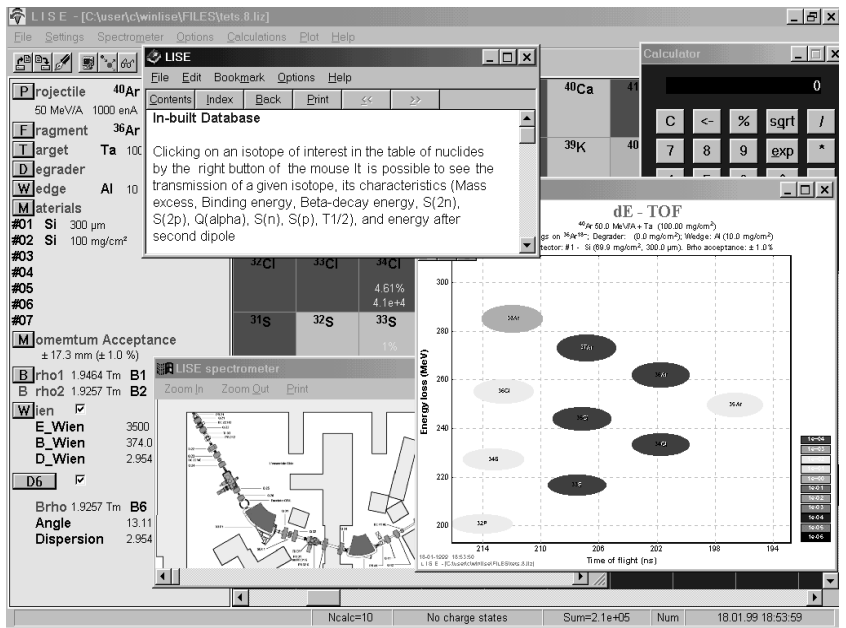
LISE operates under MS Windows

1999-
2000
O.T., GANIL
v.3.2-4.9

Active development of the LISE code
stimulated by M.Lewitowicz

LISE for Excel.
It includes even transmission calculations.

File Edit View Insert Format Tools Data Window Help					
Slits	Object size (Spot on target)	1	(±) mm	34	LISE 30 100
	Slits intermediate focal plane	30	(±) mm	35	
	Slits first focus (after Wedge)	100	(±) mm	36	
	Slits second focus (after Wien)	7.5	(±) mm	37	
Dipoles	Brho1	1.21151	Tm	38	Magnetic fields
	Brho2	1.14931	Tm	39	
	Radius 1	2.598	m	40	0.5737953 Tesla
	Radius 2	2.003	m	41	
Wien filter	<input checked="" type="checkbox"/> ENABLED			42	Recalculate Work & Util
	Electric field	2000	kV/m	43	
	Magnetic field	260.5	G	44	
	Dispersion coefficient	4.8E-04		45	
	Magnification	1		46	
	Electric length	4.4	m	47	
	Magnetic length	5.0	m	48	
Acceptances	Real/Red field	1		49	
	Max. momentum accept	5	(±) %	50	
	Target theta acceptance	17	(±) mrad	51	
	Target phi acceptance	17	(±) mrad	52	
Optics	Wedge theta acceptance	20.265	(±) mrad	53	
	Wedge phi acceptance	6	(±) mrad	54	
	Dispersion target -> wedge	17.347	mm/%	55	
	Dispersion wedge -> focal	43.931	mm/%	56	
	Magnification target -> wedge	0.788		57	
	Magnification target -> focal	1.999		58	
theta magnification at wedge	1.267		59		
theta/x coefficient at wedge	0.353	mrad/mm	60		
theta dispersion at wedge	2.802	mrad/%	61		
phi magnification at wedge	0.283		62		
phi/y coefficient at wedge	1.032	mrad/mm	63		
Angle on target		mrad	64		



2001

NSCL / MSU
v.4.10 –5.12

Active development of the LISE code stimulated by B.Sherrill.
Abrasion-Ablation model construction, ATIMA implementation

1) D.Bazin, O.Tarasov, M.Lewitowicz, O.Sorlin, NIM A 482 (2002) 314.

2002

NSCL / MSU
v.5.13 –5.15

First references ^{1,2)} since 16 years!
Fusion residues transmission ³⁾. PACE4 implementation.

2) O.Tarasov, D.Bazin, M.Lewitowicz, O.Sorlin, NP A 701 (2002) 661.

3) O.Tarasov and D.Bazin, NIM B 204 (2003) 174.

2003

NSCL / MSU
v.6

LISE++ ^{4,5)} is the new generation of the LISE code, which allows
the creation of a spectrometer through the use of different “blocks”.

4) O.T., Preprint NSCL MSU, MSUCL-1248, 45 pages

5) O.Tarasov and D.Bazin, Nuclear Physics A746 (2004) 411-414

2004

NSCL / MSU
v.7.1

Convolution Model of Proj.Frag. momentum distributions ⁶⁾
Implementation of codes Charge and Global
Coulomb Fission ^{7,8)}

6) O.T., Nuclear Physics A734 (2004) 536-540

7) O.T., Preprint NSCL MSU, MSUCL-1299, 2005, 64 pages

8) O.T., EPJ A25 (2005) 751

2005

NSCL / MSU
v.7.5

RF separation system, Isomers
Abrasion – Fission ⁹⁾

9) O.T. Preprint NSCL MSU, MSUCL-1300, 2005, 131 pages

2006

NSCL / MSU
v.7.9

Fusion – Fission ¹⁰⁾

10) O.B.Tarasov, and A.C.C.Villari, NIM B 266 (2008) 4670-4673

2007

NSCL / MSU
v.8.0

Monte Carlo calculation of fragment transmission,
Fragment production in material ¹¹⁾

11) O.B.Tarasov, and D.Bazin, NIM B 266 (2008) 4657-4664

2008

v.8.4

MC : Use of High order optics
MOTER code development, new blocks "Solenoid", "Delay block", Bunch of new utilities

2010

v.9.1

Working on 64-bit Windows OS,
MC : Extended configurations

2012

v.9.3

MC : Optics calculation up to second order inside LISE++, Utilities to develop and modify extended configurations
"DF4 distribution" class : Important updates of analytical transmission calculations

03.2013

v.9.5

Physics (^{76}Ge , ^{82}Se): EPAX3, Probability for compound nucleus formation, Abrasion-Ablation update, Momentum Distributions, Initial prefragment analysis; Optics: New block "RF-buncher"

11.2013

v.9.7

Physics: User Differential Cross Sections for Two body reactions; MC: new fields, gates optimization, input & output rate files
Optics: New blocks "Shift", "E-quad", "E-dipole";

01.2015

v.9.9

Optics: S & E blocks, revision of "Compensating dipole" block, Quadrupole & Sextupole superposition, TRANSPORT code file Import, Active construction of new extended configurations («BigRIPS», «SHELS», «MSP144+Q2», «PRISMA», «MARS» ...)

2015

Brief report of LISE++ status ¹²⁾

LISE++ porting process started!! ^{13,14)}

12) O.Tarasov and D.Bazin, NIM B 376 (2016) 185.

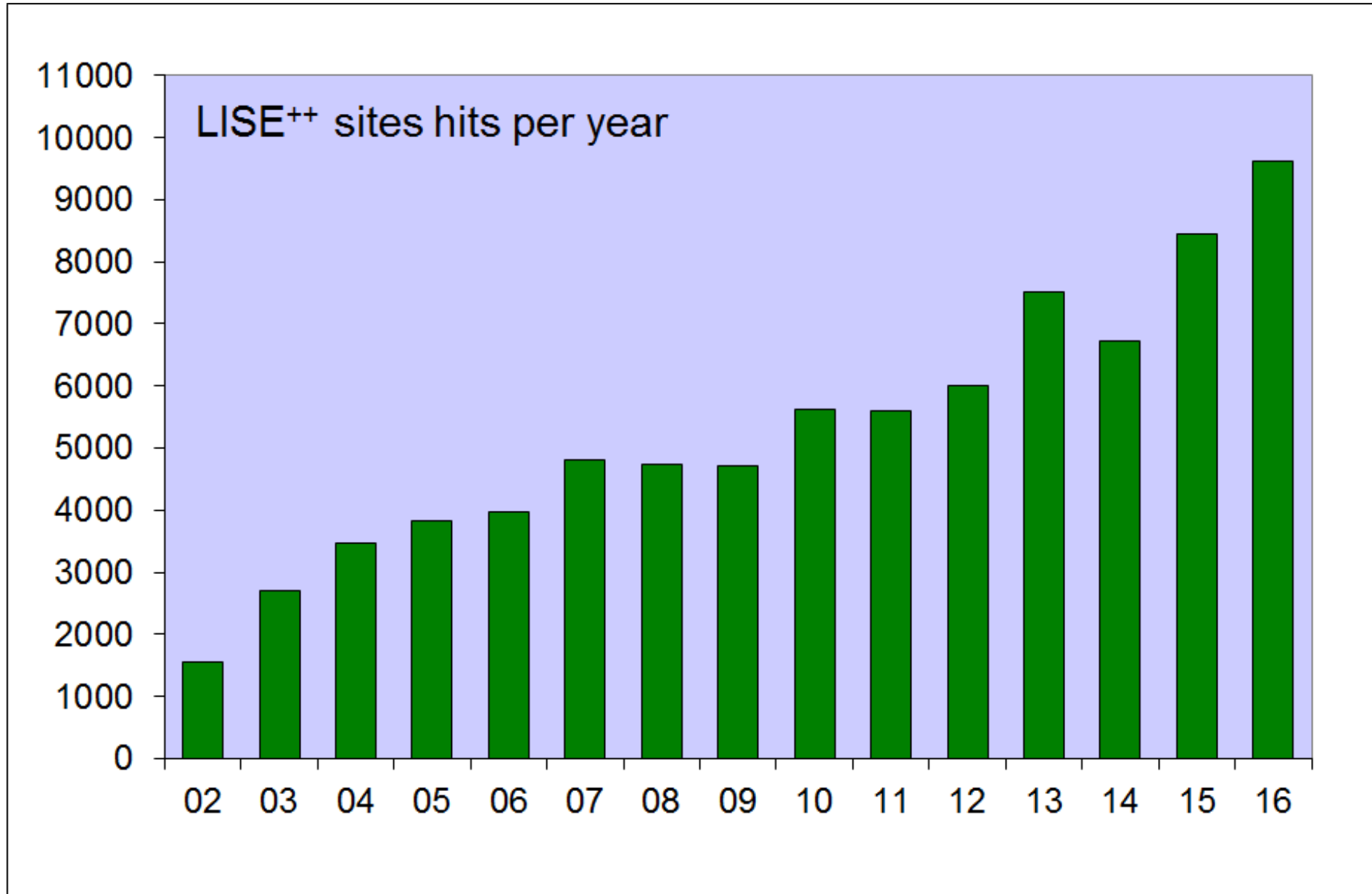
13) M.P.Kuchera, O.B.Tarasov, D.Bazin, B.Sherril, K.V.Tarasova, Journal of Physics: 664 (2015) 072029

14) M.P.Kuchera, O.B.Tarasov, D.Bazin, B.Sherril, K.V.Tarasova, NIM B 376 (2016) 168

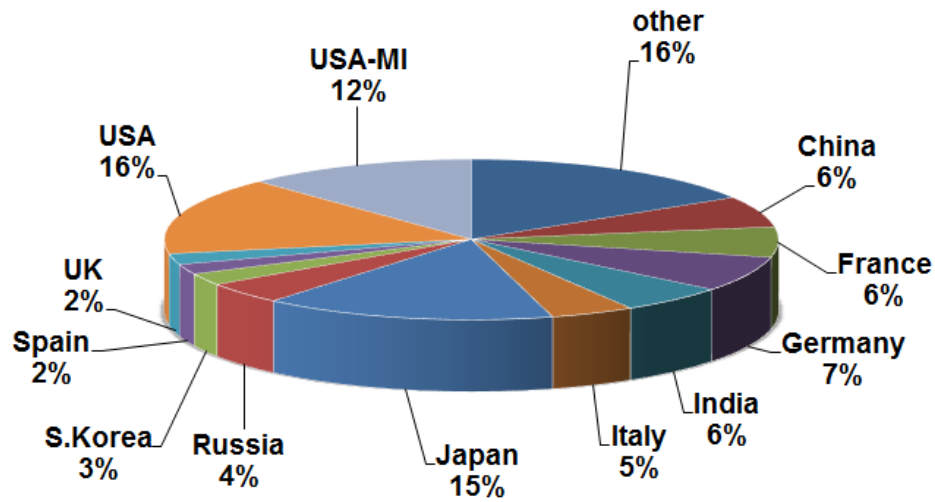
09.2016

v.9.10.345

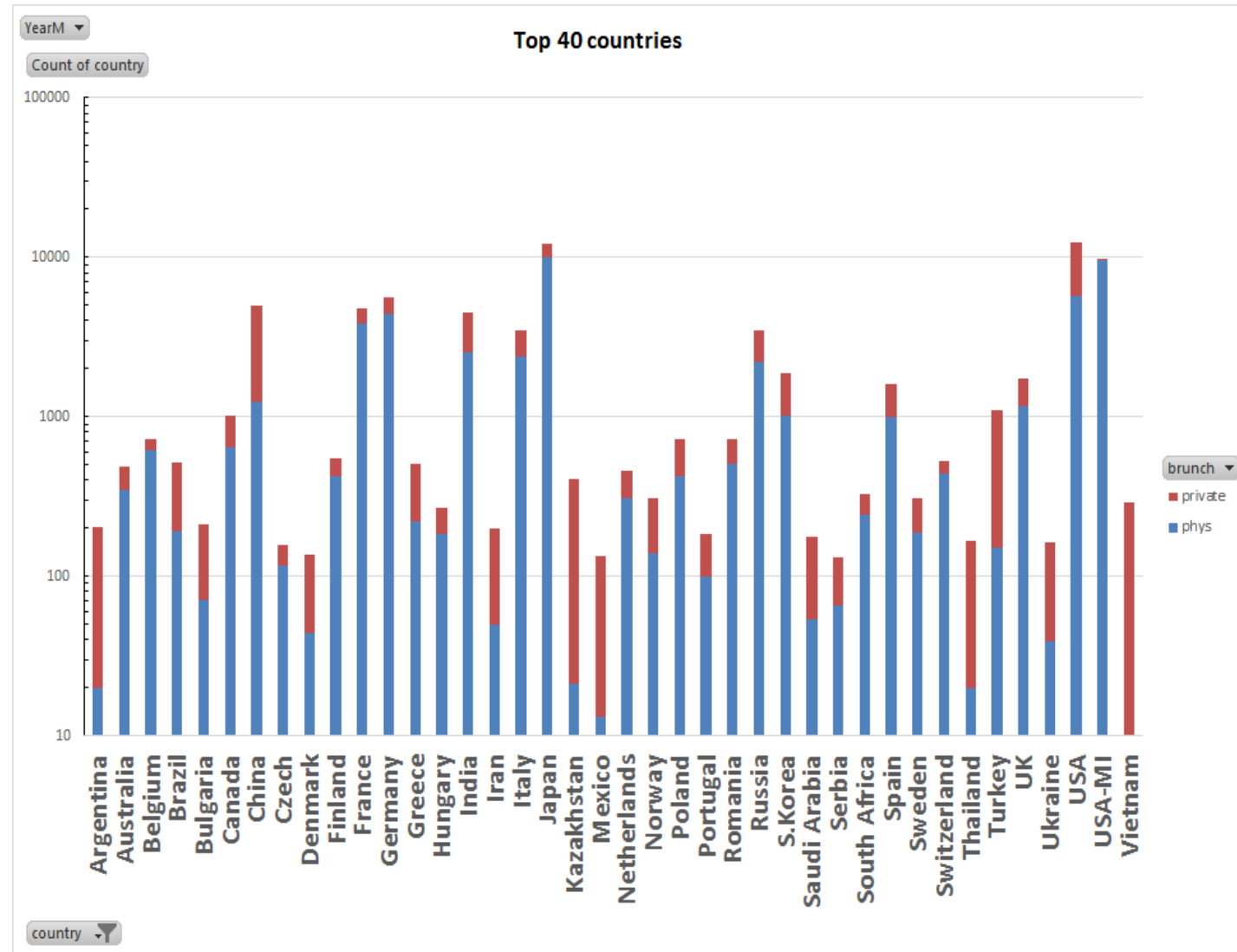
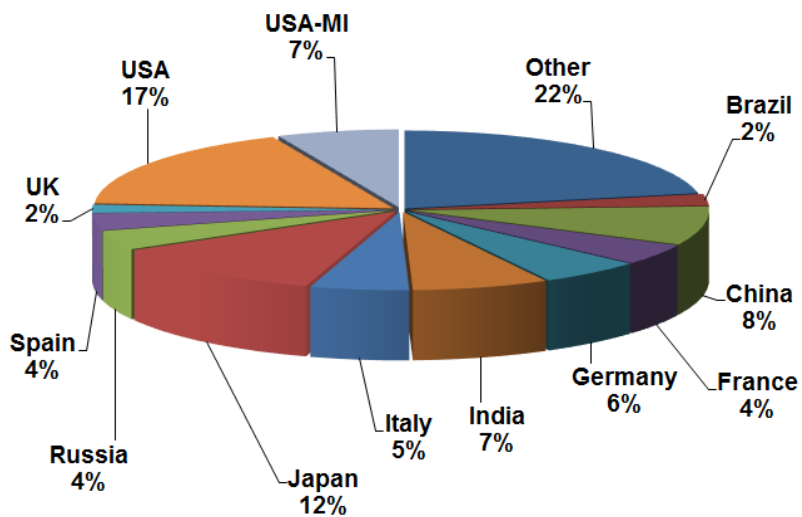
Physics: Update of Fusion reaction mechanism, Radiation Residue Calculator, ETACHA4, Ionization energy database
Optics: Beam Optics Optimization (incl. 2nd order), Reverse configuration technique, active construction of new configurations

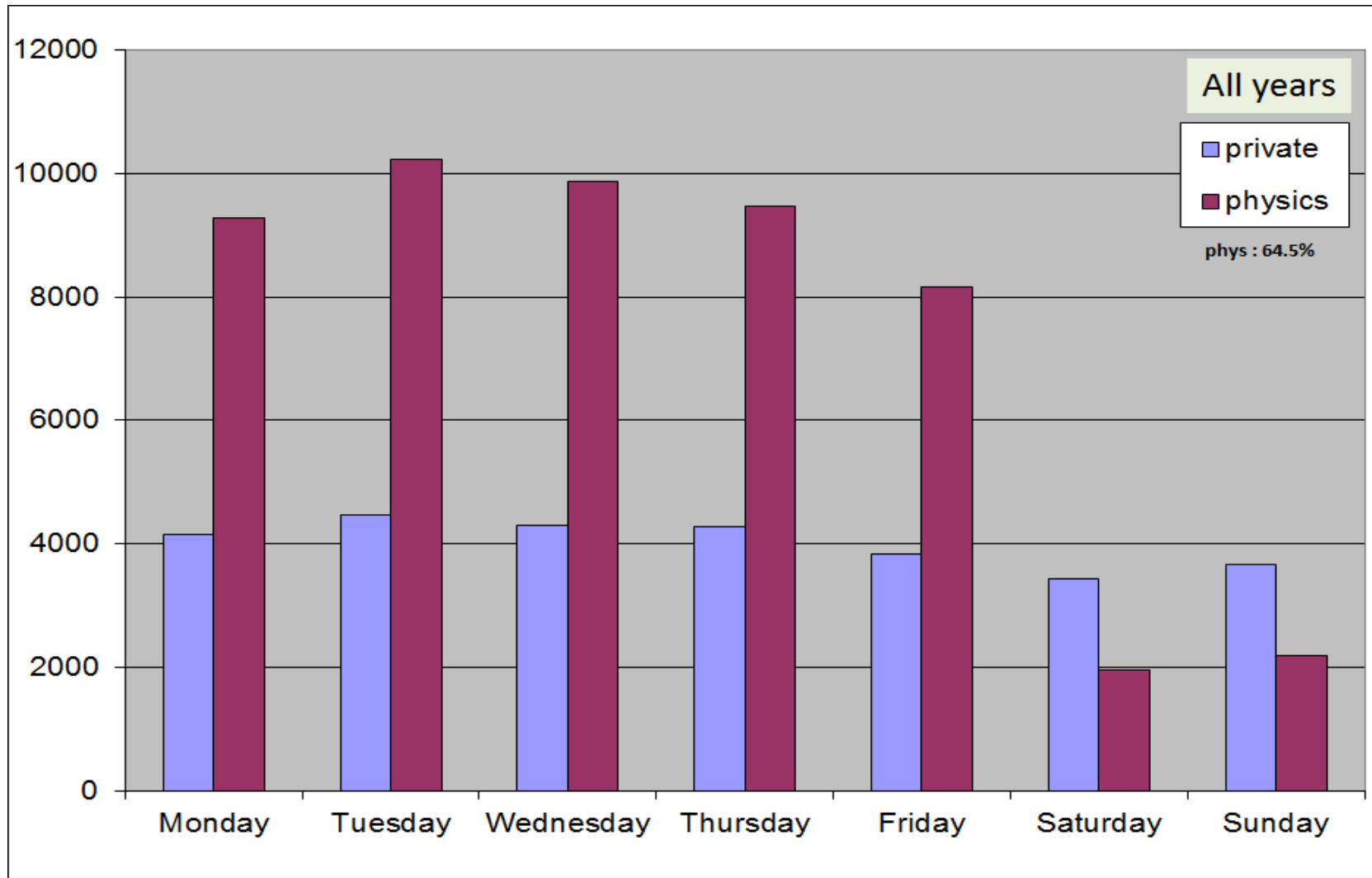


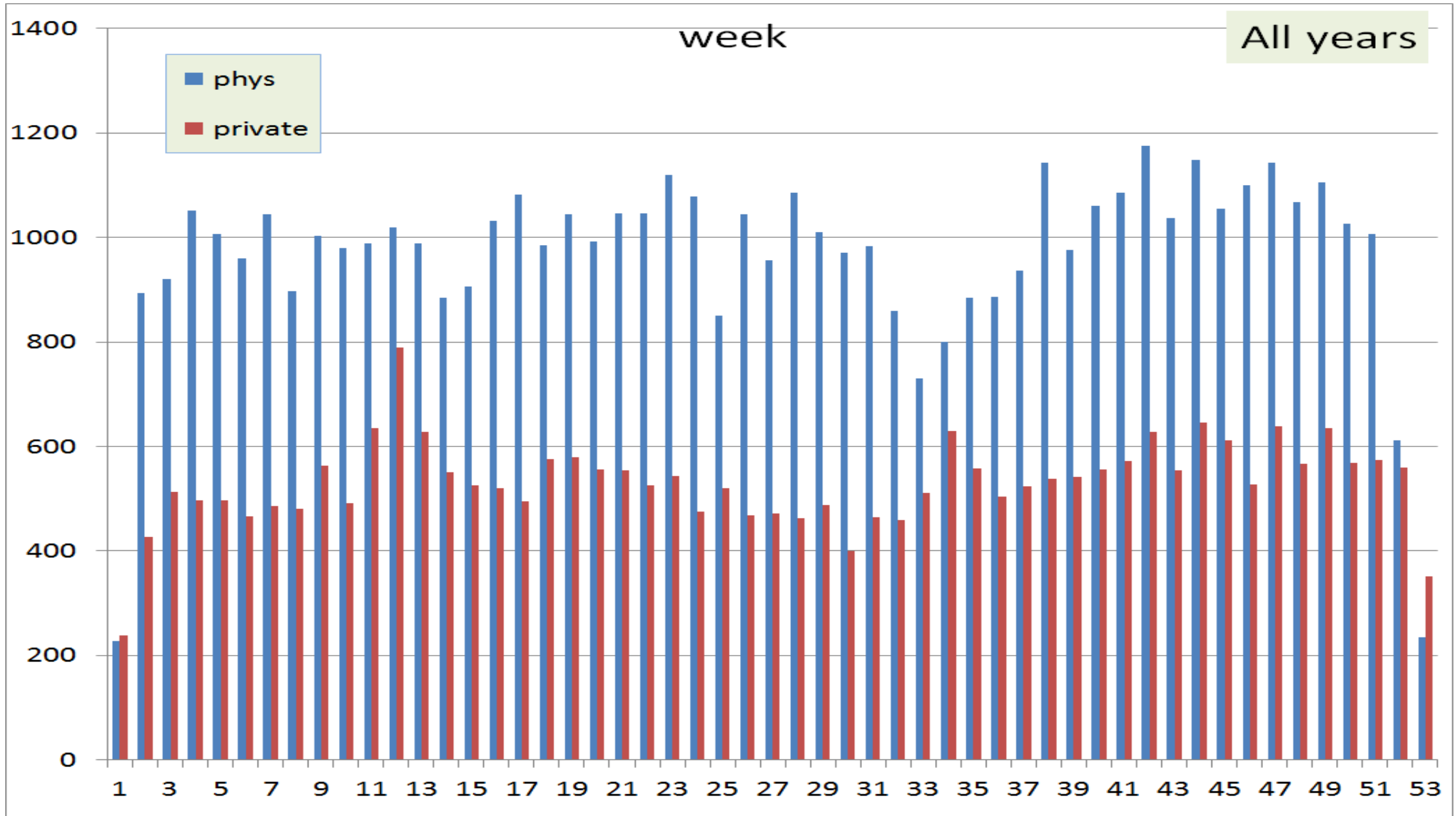
The LISE++ code geography



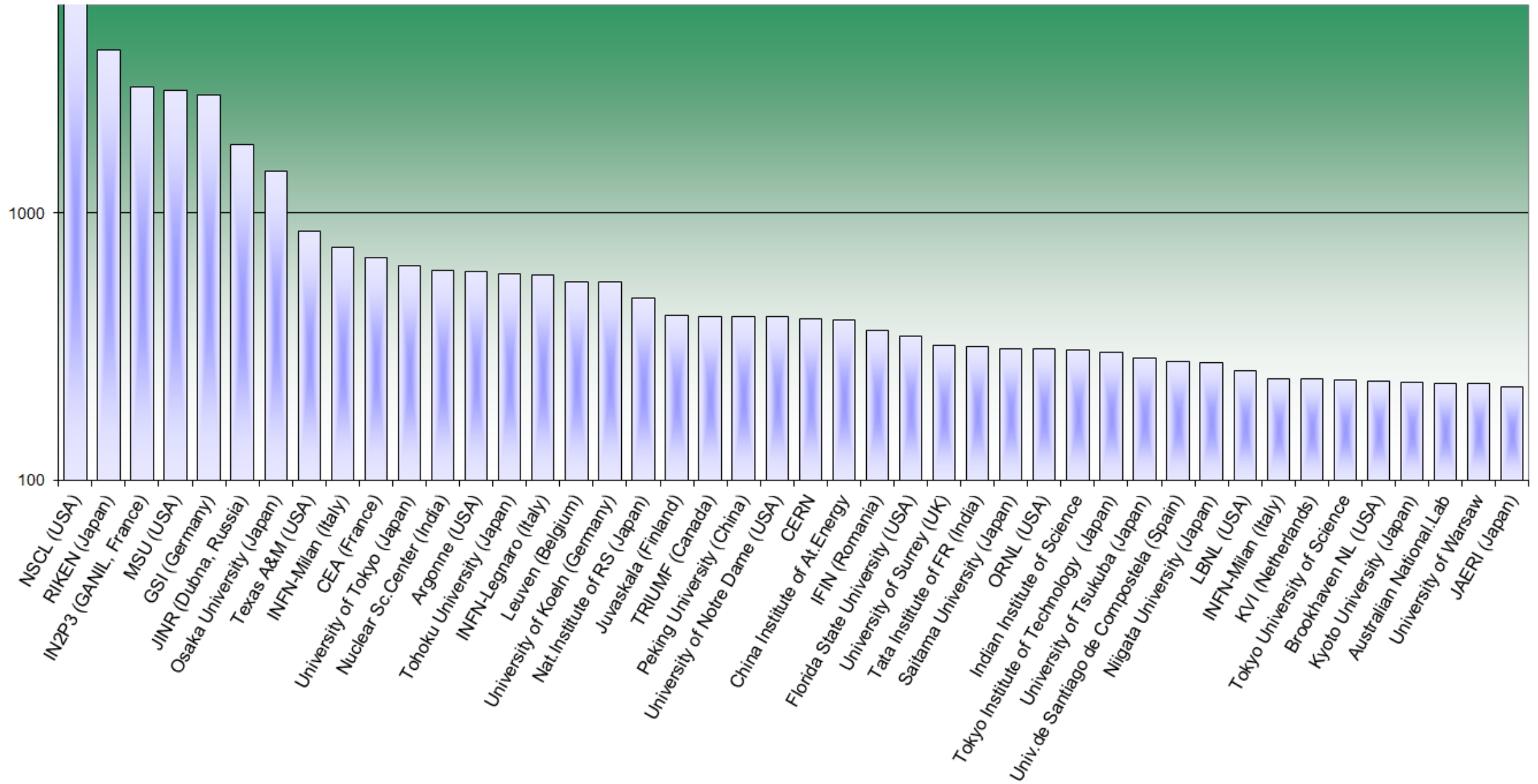
The LISE++ code geography (last 2016 year)







Laboratories (absolute values) : 2016



LISE⁺⁺ EXOTIC BEAM PRODUCTION WITH FRAGMENT SEPARATORS

LISE⁺⁺ Home
Utilities
LISE for Excel
PACE 4
MOTER
LISE utilities in Qt

Implemented codes

- [«PACE4» \(fusion-evaporation code\).](#)
- [«MOTER» \(raytracing-type program for magnetic optic system design\).](#)
- [«ETACHA4» \(charge-state distribution code\)](#)
- [«Global» \(charge-state distribution code\)](#)
- [«Charge» \(charge-state distribution code\)](#)
- [«Spectroscopic Calculator" \(of J.Kantele\)»](#)

LISE⁺⁺ calculators

- [«Physical Calculator»](#)
- [«Relativistic Kinematics Calculator»](#)
- [«Evaporation Calculator»](#)
- [«Radiation Residue Calculator»](#)
- [«Ion Mass calculator"»](#)
- [«Matrix calculator"»](#)
- [«PID resolution calculator" \(see "LISE for Excel"\)](#)

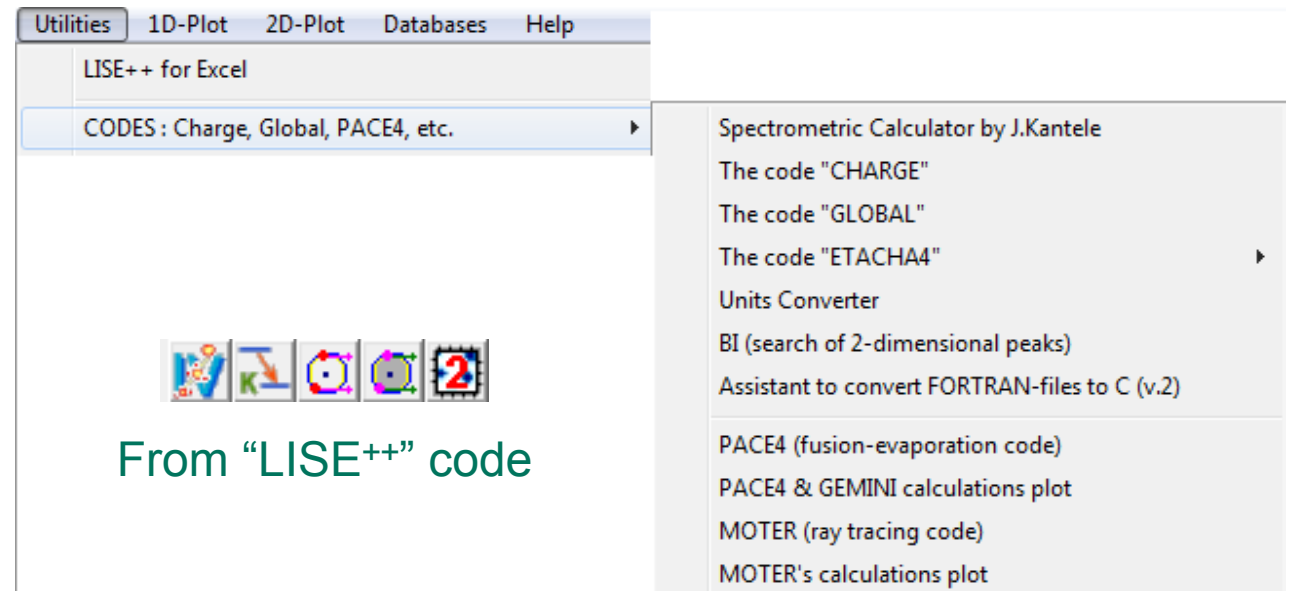
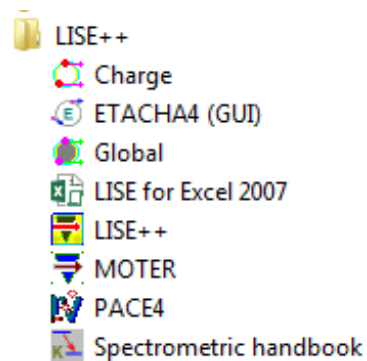
Built-in powerful tools

- [LISE for Excel](#)
- [Stripper Foil Lifetime Utility](#)
- [Brho Analyzer](#)
- [Twinsol \(solenoid\) utility](#)
- [Units Converter](#)

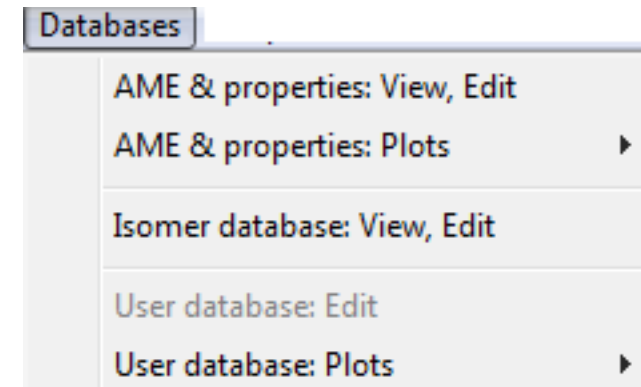
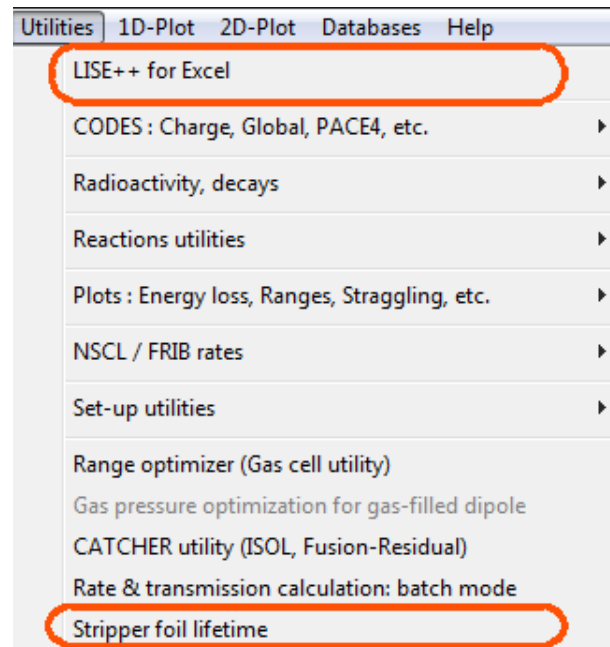
- **Implemented codes**
PACE4, Global, Charge, Moter, ETACHA, Gemini++ ...
- **General purpose utilities**
LISE for Excel, Nuclide Database plots...
- **Built-in Calculators**
Physical, Kinematic, Evaporation, Radiation Residues...
- **Specific block utilities**
Twinsol, Brho-Erho analyzer, ISOL-catcher ...
- **Production mechanism utilities**
Radioactivity utilities, Lab-CM Dif.CS converter ...
- **Optimizers**
Target thickness, Target-Wedge optimizer, RF-buncher, RF-kicker...

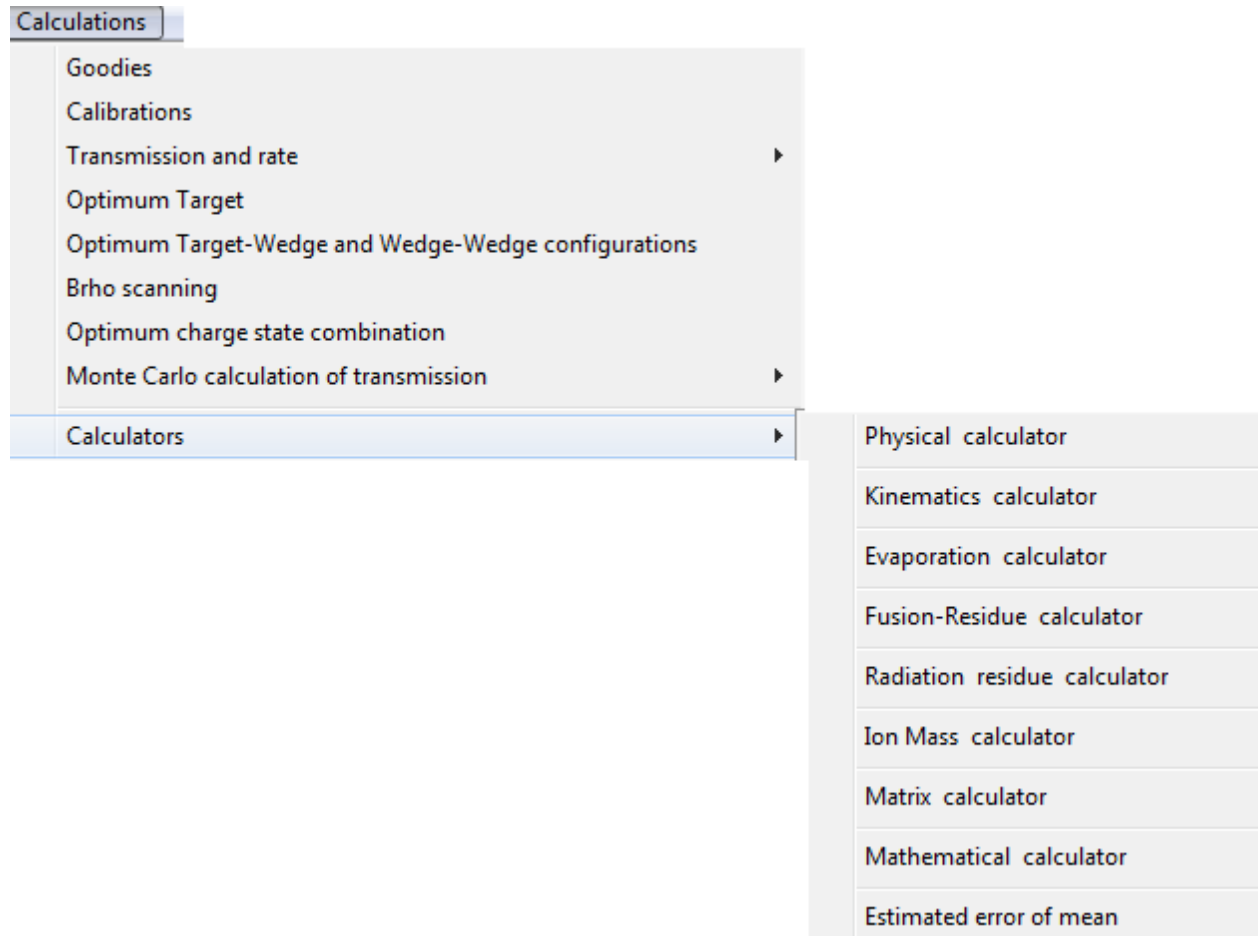
- ❑ PACE4 – evaporation MC code for Windows
- ❑ The spectrometric handbook of J.Kantele
- ❑ Units converter
- ❑ Code “Global” (charge state distributions)
- ❑ Code “Charge” (charge state distributions)
- ❑ “MOTER” ray-tracing code with optimization capabilities
- ❑ ETACHA
- ❑ GEMINI++ (Qt-version)

From “LISE++” folder



- ❑ **LISE++ for Excel**
- ❑ **Nuclide and Isomeric states Databases utilities**
- ❑ **Stripping foil lifetime**
- ❑ **Automatic search of two-dimensional peaks in experimental spectra**





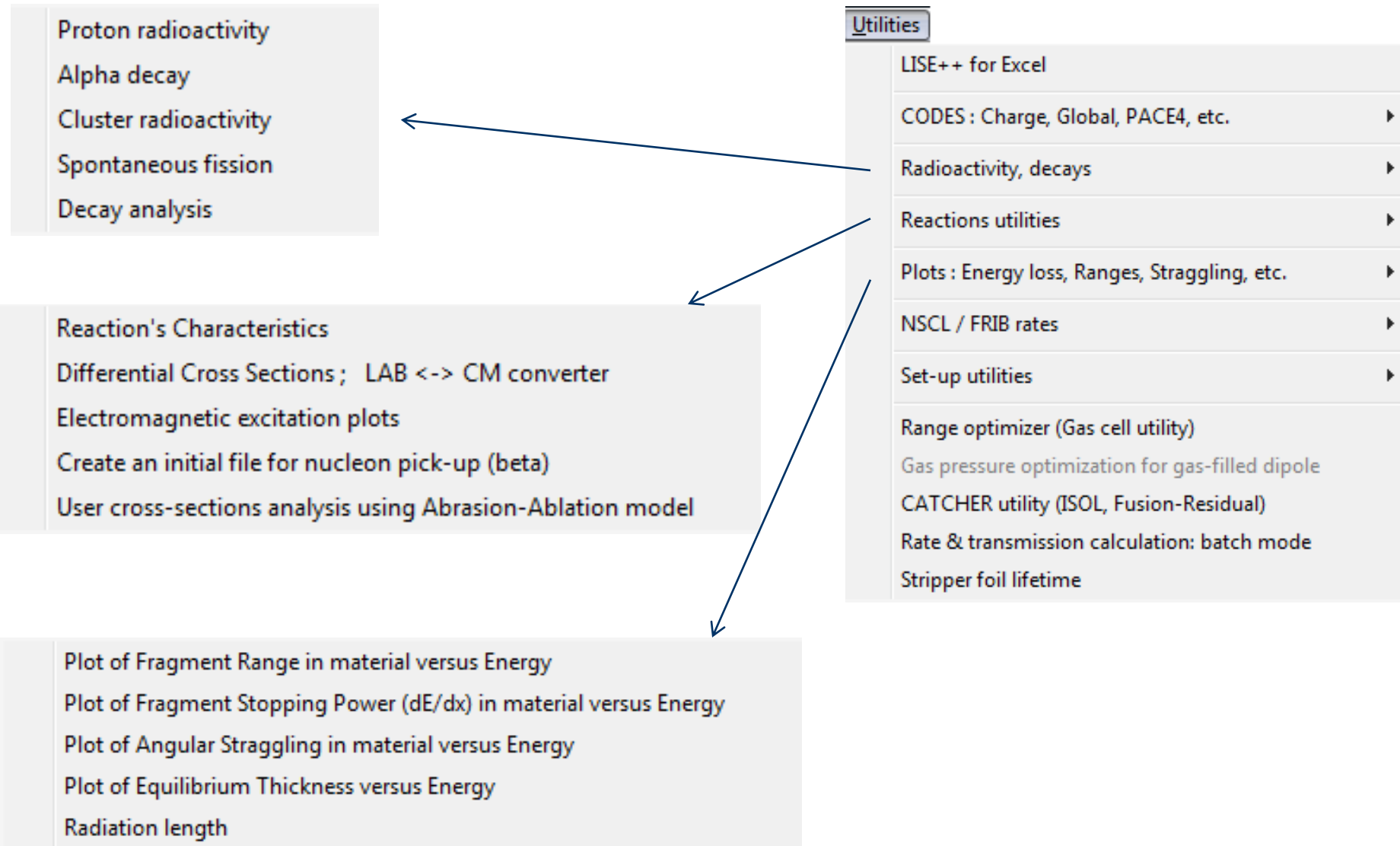
- Physical Calculator**
- Relativistic Reaction Kinematics Calculator**
- Evaporation calculator**
- Fusion-Residue calculator**
- Radiation Residue Calculator**
- Ion Mass calculator**
- Mathematical calculator**
- Matrix calculator**

- ❑ Catcher utility
- ❑ Solenoid (Twinsol)
- ❑ Range optimization (Gas Cell utility)
- ❑ Curved & Custom degraders calculation
- ❑ Brho-Erho analyzer
- ❑ MSP144 (FLNR) utility
- ❑ Beam inclination on target (GANIL)

Utilities

- LISE++ for Excel
- CODES : Charge, Global, PACE4, etc. ▶
- Radioactivity, decays ▶
- Reactions utilities ▶
- Plots : Energy loss, Ranges, Stragglings, etc. ▶
- NSCL / FRIB rates ▶
- 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



PACE4 - [Untitled]

File Page Help

Next page **CARD 1** About

NCASC number of cascades. (events in Monte Carlo calculation < 1 000 000)

INPUT

- =1 projectile + target input . AGRAZ parameter determines diffuseness of partial wave distribution
- =2 compound nucleus input for single spin.
- =3 compound nucleus input. Spin distribution read in.
- =4 compound nucleus input. Spin distribution calculated taking spin-cutoff parameter at given Ex.
- =5 triangular ($\sigma = 2I+1$) cross section between LMINN and maximum spin

FYRST

- parameter determining yrast line to be used. FYRST < 0 provides the G-C yrast line.
- < 0 Gilbert-Cameron spin cutoff parameter. $EROT = (SPIN)**2/(2.*SIGSQ)$
- != 0. EROT = rotating liquid drop rotational energy, multiplied by factor of FYRST.
- ==0 value changed to FYRST = 1. In both cases level density calculated at $E = EX-EROT$.

BARFAC

- The program assumes the A.J.Sierk modified rotating liquid drop barrier if this is equal to 0. If you provide a fission barrier of your own, the Sierk barrier will be renormalized accordingly.
- If BarFac is positive it will be taken as the desired zero spin fission barrier.
- If BarFac is negative, its absolute value will be taken as a factor to multiply the Sierk barrier.

ARATIO Ratio of the Fermi gas level density parameter 'LITTLE-A' at the saddle point to the ground state value. The saddle point level density is determined by g.s. 'LITTLE-A' * ARATIO.

FACLA level density parameter = MASS/FACLA if not zero.
if ==0 Gilbert and Cameron value used.

Limits of residual yields (in %) to show angular and energy distributions
Low limit =
High limit =

MDIR=1 - it is appropriate for deep inelastic fragment deexcitation

IDIST

- =0 brief, schematic results of particle spectra and list of evaporated (residual) nuclei
- =1 detailed angular and energy distribution of residual nuclei and evaporated particles.
- =2 detailed(1) + transmission coefficients for particle emission

MDIR

- = 0 Compound nucleus is initially in $M=0$ states and the Z-axis is the recoil axis.
- = 1 Compound nucleus is initially in $M=J$ states, the Z axis is perpend. to recoil direction.

ITRAC - it controls the degree of event traceback

- = 0 produces compact traceback, summed over all residues.
- = 1 detailed traceback leading to each individual isotope separately.

NOSHL

- =0 uses AME2003 values (A,W&T, NPA 729, 2003, pp.336-676)
- =1 uses Lysekil masses with shell correction

Particle analysis

- Create output file
 - neutron
 - proton
 - alpha
 - gamma

Nucleus Gate

- Use
 - A =
 - Z =

Updates:

- Masses from the AME2012 database
- Quantum-mechanical transmission probability for one-dimensional barrier
- Batch mode
- Detailed decay analysis options
- Possibility to plot

About PACE4

PACE4
fusion-evaporation code

This is a modified version of JULIAN Monte-Carlo code coupling angular momentum

P A C E - Projection Angular-momentum coupled Evaporation

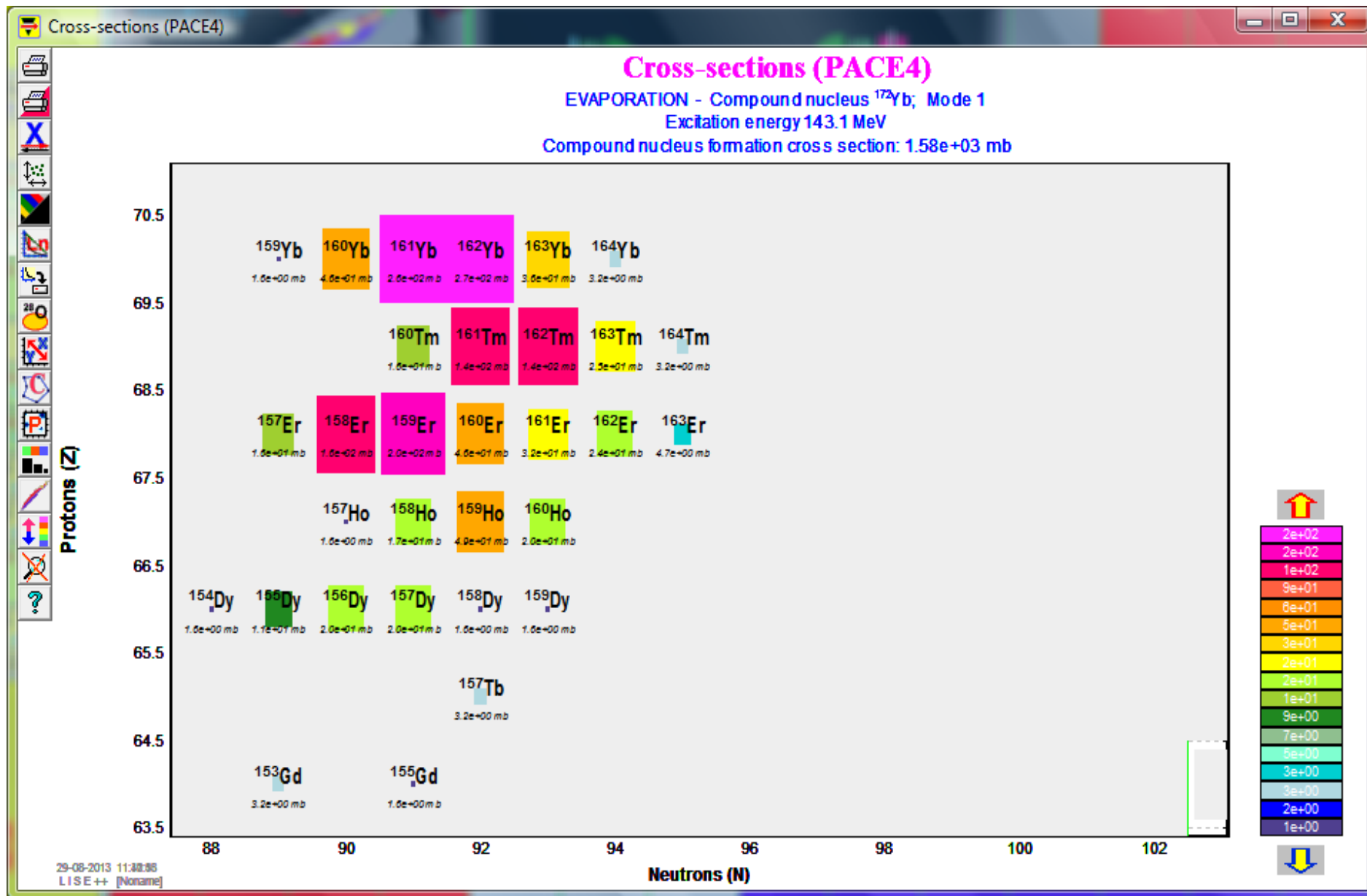
M.Hillman and Y.Eyal (code Julian)
Avigdor Gavron (code PACE2)

Version 4.22
Last revision 28-JUN-2017

This program has been ported to Windows from FORTRAN to C++, updated (AME database, QM tunneling approach, Utilities, Plots and so on) within the framework of the program LISE++ by O.B.Tarasov

lise.nsl.msu.edu/pace4 **LISE**

for citations please use the following: O.B.Tarasov, D.Bazin, NIM B (2008) 4657, A.Gavron, Phys.Rev. C21 (1980) 230-236



Spectrometric calculator of J.Kantele

ElecStop	Electron	Elem	EtoPos	FermiFun	FermiOld	FK_Energ	FK_EnPos	FK_Momen	GammaFun	GamSpeed		
HalfLife			ICCK	ICCTot	Ion	lgFT_bet	lgFT_EcB	LlonLoss	LlonStop	LlonTran	LlStop	
Act	AnaState	AttGamma	Barrier	CaptuRat	ChrgStat	Clebsch	CompNucl	Compton	ConverSI	ConvertE	CurveFit	Doppler
Metag	Monopole	MulScatt	NegaShap	Omega	OmegaGen	OmegaPF	PosiShap	QuickRan	Qvalues	Reaction		
Recoil	Rutherf	Screeneg	ScreenPos	SolidAng	TargHeat	WeighAve	Z_A_rel	Z_eff	Z_per_A			

The upper limit of the temperature of a uniform target under uniform ion-beam bombardment. The beam spot and the target are concentric circles with radii R1 and R2. The heat $P = I \cdot S \cdot D$ is removed by mere conduction $P(\text{cond})$ or by mere radiation, $P(\text{rad})$. The temperature of the environment is taken $T(0) = 295 \text{ K}$. $T(\text{max})$ for each case is computed. The dependence of thermal conductivity K, emissivity E, or stopping power S on the temperature T is ignored.

Target thickness, D = mg/cm² Radius of beam spot, R1 = mm

Density of the target material, rho = g/cm³ Radius of target, R2 = mm

Stopping power dE/dx, S = MeV/mg/cm² Emissivity of the beam spot, E = (aver. of two sides)

Thermal conductivity of the target foil, K = W/mK Beam intensity, I = particle microAmps

Auxiliary data table

Beam heats the target with total power P = **9.53** W

For mere conduction losses, T(max) = T(center) = **3.65e+03** C

For mere radiation losses, T = **3.38e+03** C

note: in practice, because of non-uniformities in beam and/or target, the true max. temperature may be much higher.

Page index: 54

About Handbook

LISE Nuclear spectrometry handbook of J.Kantele

Beta Decay, Decay of Excited States, Interaction of Radiation with Matter, Beta-ray and Conversion-electron Spectrometry Calibration Standards, Nuclear Reaction Experiments

The program is transferred under OS MS Windows by O.B.Tarasov on the basis of the Handbook of nuclear spectrometry of J.Kantele (Academic Press Limited, 24-28 Oval Road, London NW1 7DX, Copyright 1995) within the framework of the program LISE. V 2.1.2 12-JUNE-2015

LISE++ lise.nsl.msu.edu

Handbook www.academicpress.com/physics/atomic.html

N	Program	Enable	Description
1	Act	yes	Production of Radioactive Nuclei
2	AnaState	yes	Coulomb Displacement and Excitation Energies
3	AttGamma	yes	Attenuation of Photon Beams
4	AttQuick	absent	Simple Formula for Photon Half-thickness Estimate
5	Barrier	yes	Coulomb and Interaction
6	CaptuRat	yes	Capture Ratios in Elec
7	ChrgStat	yes	Average Equilibrium Ch. in Matter
8	Clebsch	yes	Clebsch-Gordan (Vector
9	CompNucl	yes	Velocity, Kinetic and Compound Nucleus
10	Compton	yes	Parameters in Compton
11	ConverSI	yes	Conversion of 10 Quant
12	ConvertE	yes	Flexible Conversion of and Momentum
13	CurveFit	yes	Fitting of Several Typ
14	Doppler	yes	Doppler Shifts and The
15	ElecStop	yes	Ranges and Stopping Po
16	Electron	yes	Speed, Bp and Ranges o
17	Elem	yes	Electron Binding and X
18	EtoPos	yes	Electron-capture to Po

N	Program	Enable	Description
19	FermiFun	yes	"Proper" Fermi (Coulomb) Functions for β^- and β^+ Decays
20	FermiOld	yes	Traditional Fermi (Coulomb) Functions for β^- and β^+ Decays
21	FK-Energ	yes	Fermi-Kurie Analysis of Electron Energy Spectrum
22	FK-EnPos	yes	Fermi-Kurie Analysis of Positron Energy Spectrum
23	FK-Momen	yes	Fermi-Kurie Analysis of Electron Momentum Spectrum
24	GammaFun	yes	Calculation of Modulus of Gamma Functions
25	GammaSpeed	yes	Weisskopf Estimates of Predictions for $B(E2;)$
26	HalfLife	yes	Half-life of Single-co
27	HionLoss	no	Energy Loss of Heavy Io
28	HionStop	no	Ranges and Stopping Po
29	ICCK	yes	Internal-conversion Coe
30	ICCTot	yes	Total Internal-convers:
31	Ion	yes	Ion Velocities and Mag
32	lgFT-bet	yes	Determination of log ft
33	lgFT-EcB	yes	Calculation of log ft Decay
34	LionLoss	yes	Energy Loss of Light Io
35	LionStop	yes	Ranges and Stopping Po
36	LionTran	yes	Residual and Deposited Transmission

N	Program	Enable	Description
39	Matters	absent	Quick Reference Table on Properties of Some Materials
40	Metag	yes	Fissility and SF Half-lives of Shape Isomers
41	Monopole	yes	$X(E0/E2)$, $B(E2)$ and ρ^2 in $E0/E2$ Transitions
42	MulScatt	yes	Rms Angle for Multiple Scattering of Charged Particles
43	NegaShap	yes	Shapes of Allowed β^- Energy Spectra
44	Omega	yes	Electronic Factors Ω for $E0$ Transitions
45	OmegaGen	yes	General, Simplified Ω KL Calculations
46	OmegaIPF	yes	Electronic Factors Ω IPF for $E0$ Transitions
47	PosiShap	yes	Shapes of Allowed Positron Energy Spectra
48	QuickRan	yes	Simple Program for Electron Ranges $R(ex)$ and $R(99)$
49	Qvalues	yes	Nuclear Reaction Q Value Calculation
50	Reaction	yes	Kinematics of Simple Nuclear Reactions
51	Recoil	yes	Recoil Effects in Gamma-, Beta-, Electron and Alpha-emission and in Spontaneous Fission
52	Rutherf	yes	Rutherford Scattering Cross-sections
53	Screeneg	yes	Screening Correction for Electron Fermi Functions
54	SreenPos	yes	Screening Correction for Positron Fermi Functions
55	SolidAng	yes	Solid-Angle Calculation in Simple Cases
56	TargHeat	yes	Beam Heating and Temperature of Self-supporting Foil
57	WeighAve	yes	Calculation of Weighted Averages
58	Z-A-rel	yes	Atomic Weight of Element Z

Units converter

Power | Time | Angle | Temperature | Cyrillic
 Length | Area | Volume | Mass | Pressure | Energy

1000 erg
 0.0001 J (joule)
 1e-07 kJ (kilojoule)
 2.3901e-05 cal
 2.3901e-08 kcal
 2.7778e-11 kWh
 2.7778e-17 GWh
 9.4845e-08 BTU
 6.2415e+14 eV
 6.2415e+11 keV
 6.2415e+08 MeV

About

Units converter

Power | Time | Angle | Temperature | Cyrillic
 Length | Area | Volume | Mass | Pressure | Energy

1000 mm³
 1 cm³ (mlitre)
 0.001 dm³ (litre)
 1e-06 m³
 0.061024 cubic inches
 0.033814 fluid ounces
 0.0021134 pints
 0.0010567 quarts
 0.00026417 gallons (U.S.)
 3.5315e-05 cubic feet
 2.8378e-05 bushels
 6.2898e-06 barrels

About

Units converter

Length | Area | Volume | Mass | Pressure | Energy
 Power | Time | Angle | Temperature | Cyrillic

273.15 K (Kelvin)
 0 C (Celsius or Centigrade)
 32 F (Fahrenheit)
 491.67 R (Rankine)

About

LISE *Units converter*

The program calculates the values of the following quantities in several different units:
 Length, Area, Volume, Mass, Pressure, Energy, Power, Time, Angle, Temperature, and ... Cyrillic converter

The program is developed by O.Tarasov on the basis of the Handbook of nuclear spectrometry of J.Kantele (Academic Press Limited, 24-28 Oval Road, London NW1 7DX, Copyright 1995) within the framework of the program LISE++

LISE++ lise.nscf.msu.edu
 Handbook
www.academicpress.com/physics/atomic.html

Global

File Help

Projectile

A	Element	Z	Z-Q	Initial Energy =	MeV/u
238	U	92	2	430	

Target

A	Element	Z	9.4762e+20 atoms/cm2	Thickness =	mg/cm2
63.55	Cu	29		100	

Loop

- no loop
- over Z(projectile)
- over incident energy
- over incident Q state
- over Z(target)
- over target thickness

Options

- Q-state at target exit (E init)
- Q-state at target exit (E final)
- Equilibrium Q-states (E init)
- Equilibrium Q-states (E final)
- Evolution of Q-states

Frequency of output

- 1/10
- 1/100
- 1/1000
- 1/10000

Output of cross sections

Plot Q-array from = 0

ready

```

GLOBAL: Q-states of heavy ions behind matter layers
-----
***** Global *****   Version 3.8   *****   29-08-2013   11:48:38
-----
(Z=92 A=238 Qe=2) at E=430.0 MeV/u on (Z=29 A=63.5 D=100 mg/cm^2)
Q-states at target exit (E init):
-----
D(mg/cm2)  D_eq    Eout    Qmean  dQ    *|    Q(0 )    Q(1 )    Q(2 )    Q(3 )    Q(4 )    Q(5 )
-----*|-----
100.00    162.20  422.3   91.26  0.70  *|    4.065e-01  4.467e-01  1.438e-01  2.887e-03  2.793e-05  1.632e-07
  
```

About "Global"

Global

calculating charge state distributions

www-linux.gsi.de/~weick/charge_states/

W. E. Meyerhof

C. Scheidenberger, Th. Stöhlker, W. E. Meyerhof,
H. Geissel, P. H. Mokler, B. Blank
Nucl. Instr. and Meth. B 142 (1998) 441

Version 4.02
30-Mar-2017

This program has been ported to MS Windows
(from FORTRAN to C++) by O.B.Tarasov
within the framework of the program LISE++.
Updated by H.Weick (GSI)

LISE

lise.nsl.msui.edu

Charge

File Help

Projectile

Element Z Energy = 1000 MeV/u

Au 79

Initial charge state distribution

	Z-Q=0	Z-Q=1	Z-Q=2
fractions	1	0	0
normalization	1	0	0

Target

Al Z = 13

Thickness 100 mg/cm²

2.2320e+21 atoms/cm²

Cross sections

Non-radiative electron capture (NRC)

EIKO (01) = 8.9668e-01 barn
 EIKO (12) = 6.3614e-01 barn

Radiative electron capture (REC)

REC (01) = 7.9589e+01 barn
 REC (12) = 4.5684e+01 barn

Ionization cross section

BORN (10) = 8.6268e+02 barn
 BORN (21) = 1.7437e+03 barn

Double cross section

DCAP (02) = 8.9668e-02 barn
 DION (20) = 8.6268e+01 barn

Equilibrium Charge State

	Z - Q = 0	Z - Q = 1	Z - Q = 2
	9.128e-01	8.503e-02	2.197e-03
Equilibrium thickness		mg/cm ²	atoms/cm ²
This code		4.8801e+02	1.0892e+22
Thieberger et al.		2.2826e+02	5.0946e+21

Charge distribution after target

Init. condition	0 el.	1 el.	2 el.
user	9.241e-01	7.419e-02	1.683e-03
for Z-Q=0	9.241e-01	7.419e-02	1.683e-03
for Z-Q=1	7.962e-01	1.967e-01	7.115e-03
for Z-Q=2	7.050e-01	2.696e-01	2.544e-02

About CHARGE

CHARGE
 calculating charge state distributions

www-aix.qsi.de/~scheid/html_charge.html

Thomas Stöhlker
 GSI & University of Frankfurt


C. Scheidenberger, Th. Stöhlker et al,
 Nucl. Instr. and Meth. B 142 (1998) 441

Version 1.3
 23-Oct-2003

This program has been ported to MS Windows
 (from FORTRAN to C++) by O.Tarasov
 within the framework of the program LISE++

lise.nscf.msu.edu

<http://lise.nsl.msui.edu/moter.html>



SIMULATION OF FRAGMENT SEPARATORS

MOTER : raytracing code with optimization capabilities
operating under MS Windows

MOTER is a raytracing-type program for magnetic optic system design. It is based on the program RAYTRACE, and includes the capability of optimizing system parameters.

The MOTER code has been rewritten from FORTRAN to C++ and transported to MS Windows operating system at 2007 by Oleg B. Tarasov^a, and Sergey V. Lobastov^b. This new development was initialized and supported by Prof. Brad Sherrill^a and Prof. Dave J. Morrissey^a. Nowadays the MOTER code is still under development by Oleg Tarasov and Marc Hausmann^a. This work was supported by DOE #DE-FG02-06ER41413, NSF #PHY-06-06007 grants.

The MOTER code can be installed free through the LISE++ installation package.

[a] - NSCL/MSU,USA
[b] - FLNR/JINR, Dubna, Russia

MOTER status (August 1, 2008)

[part 1 "Development" by Oleg Tarasov \[PDF \(1.4 MB\)\]](#)
[part 2 "Application" by Marc Hausmann \[PDF \(6.5 MB\)\]](#)

The origins of MOTER

by H.A.Thiessen and Morris M.Klein
Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545

Kenneth G.Boyer
University of Texas, Austin, Texas 78712

MOTER is a raytracing program intended for analysis and optimization of systems of magnetic elements. Several features are included in MOTER which are not available in other codes. Among these are Monte Carlo simulation of the beam phase space, a sophisticated definition of the performance including the possibility of computer correction of aberrations based on measurements of the trajectory of each event, the automatic optimization of any parameter of the magnet system, the possibility of the use of field maps for dipoles, quadrupoles, and multipoles, and the availability of several new element types including an ExR separator, an

- Home
- Introduction
- Documentation
- Last Changes
- Perspectives
- Download
- MOTER
- PACE 4
- Spectrometers
- Related topics
- Personal pages
- Registration
- Email

The Development has been frozen. If do you wish... ?

MOTER7 - A1900_06_negativeXCR_v2

Project: Help

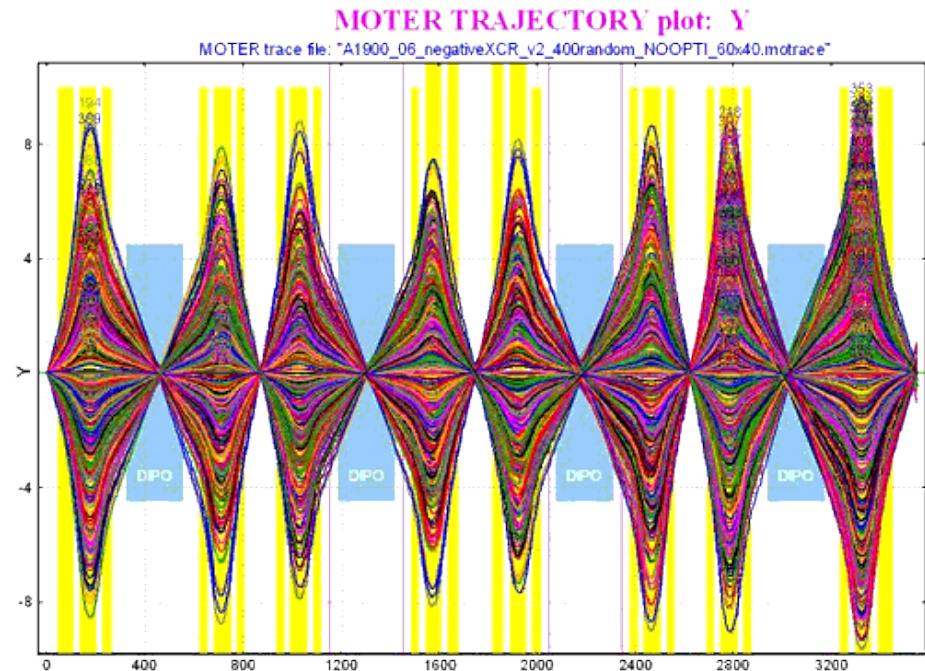
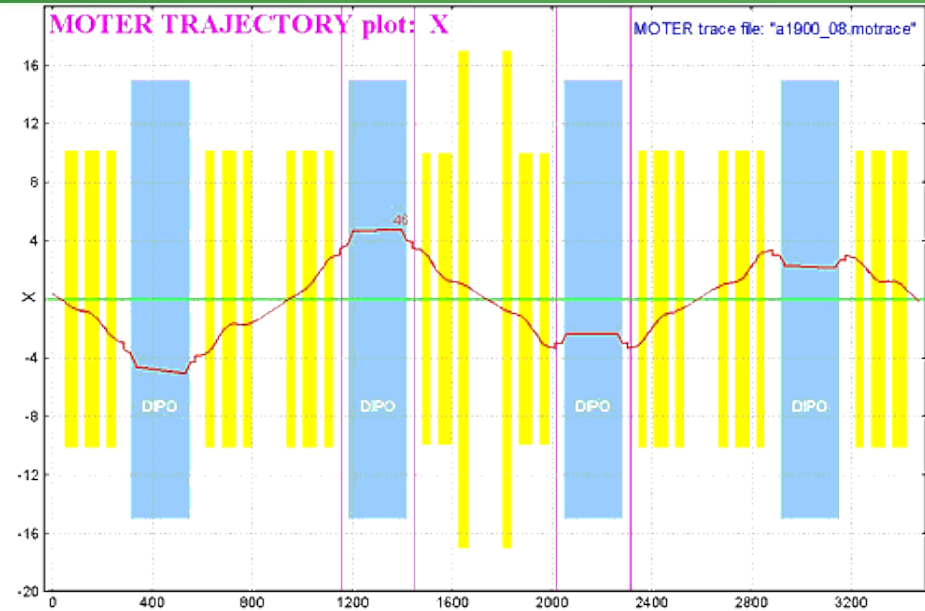
BETA Version 2.1.8

Preferences | Optimization | Demand | Magnet1 | Magnet2 | Elements | FileLogs | Results

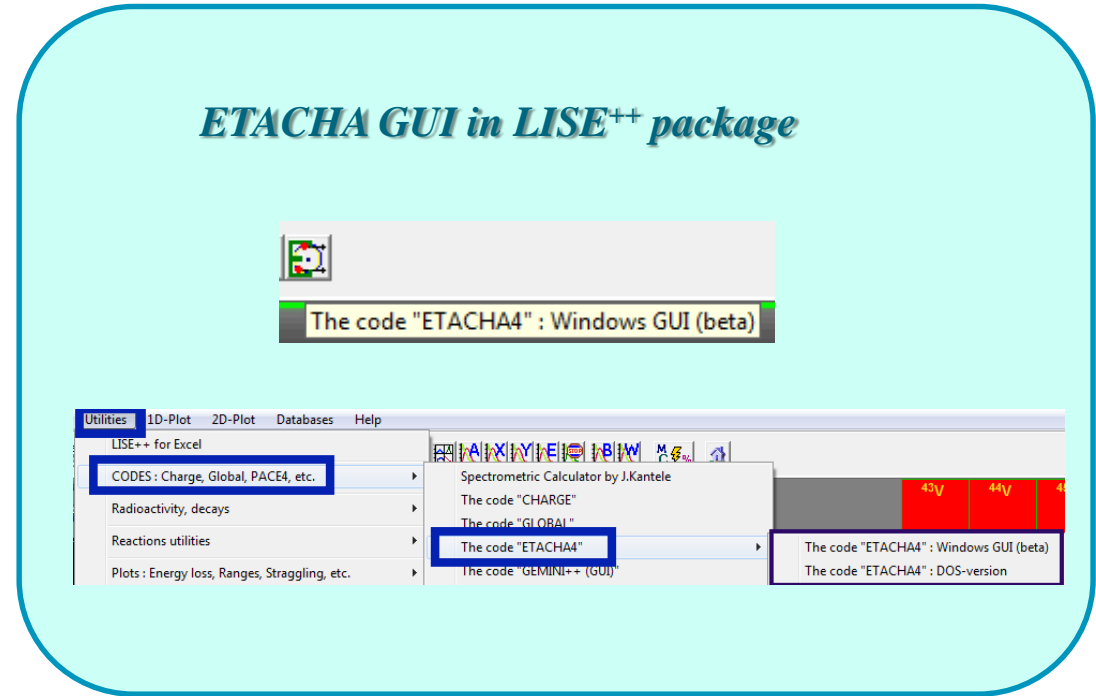
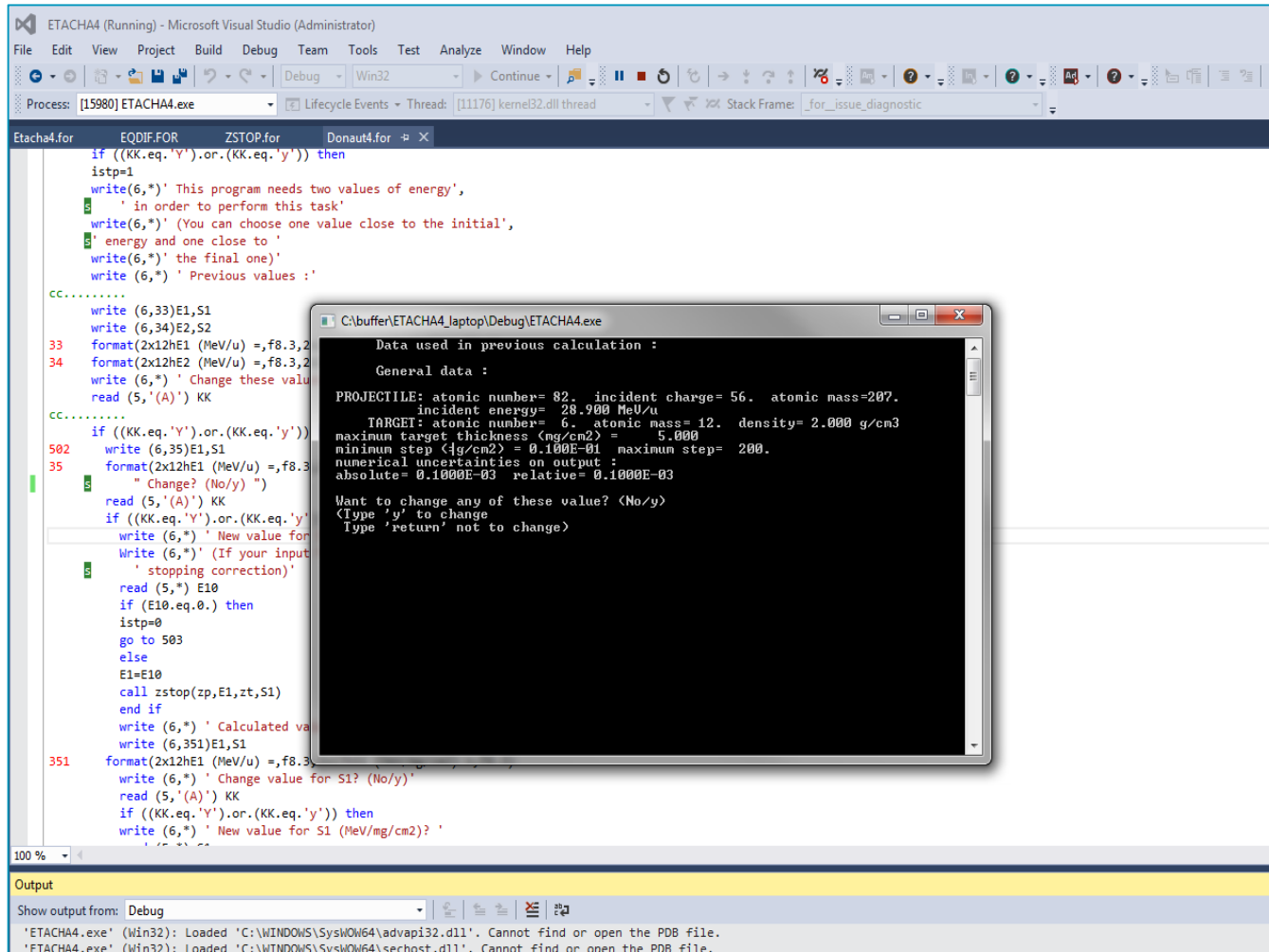
Magnet tab (file: MAG) — this file defines the magnetic system and the phase space to be simulated

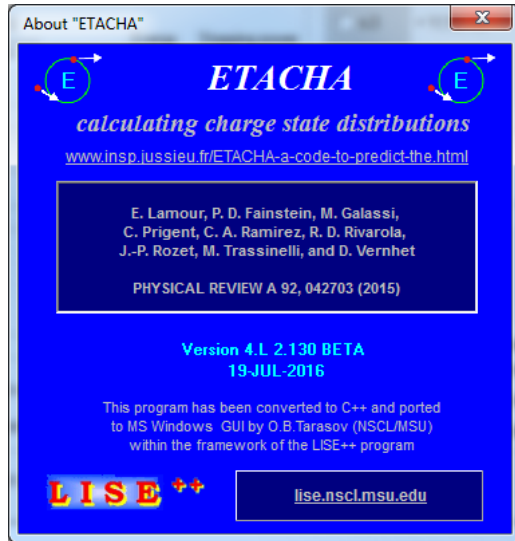
Line	Variables	Value	Type	Default	Comments
1	NTITLE	A1900_06 G19V4M6 at 3 Tm GICOSY Enge from DB			A*80 Title
2	NR	13	I	100	Number of rays; 400 MAXIMUM
	NP	1	I	1	Print option as in RAYTRACE
	NSKIP	1	I	0	?
	JRAND	0	I	1	doRandom
	ICON	1	I	0	0(1) Demand coefficients calculated after each pass
	NRAND	0	I	1	Number of normally distributed random errors for each ray
	ITUNE	0	I	0	Not used, should be 0
3	OPTI	ISNG -> single pass calc w/error fuctions			Method (OPT)
5	IRANDUM	0	I	0	Normally=0 (=1 use rand seed)
	IRANSTA	0	I	0	=0 unless IRANDUM=1 then this is seed
6	ENERGY	899.378	R		Particle Momentum (MeV/c)
	RM	1	R	1	Mass in amu
	CHARGE	1	R	1	Charge
8	NINDEPN1	1	I	0	Number of independent variables
	ISET	1	I	1	must be 1
9	DELTA(L)	0.01			Uncertainty in independent variables L. Normally set these variables to 0.01 If you get *OPTIM 300, ERROR FALTY, increasing to 0.03, or higher.
10	LPRIMP(L)	0 8 18 28 36			Position to print ray data. Use 0 to signal no more positions wanted, but all 10 spaces must have values; e.g. 0.5,10,-1,0,0,0,0,0 would be used to see the ray data at locations 0.5 and 10.

Target Image Image Focal Plane



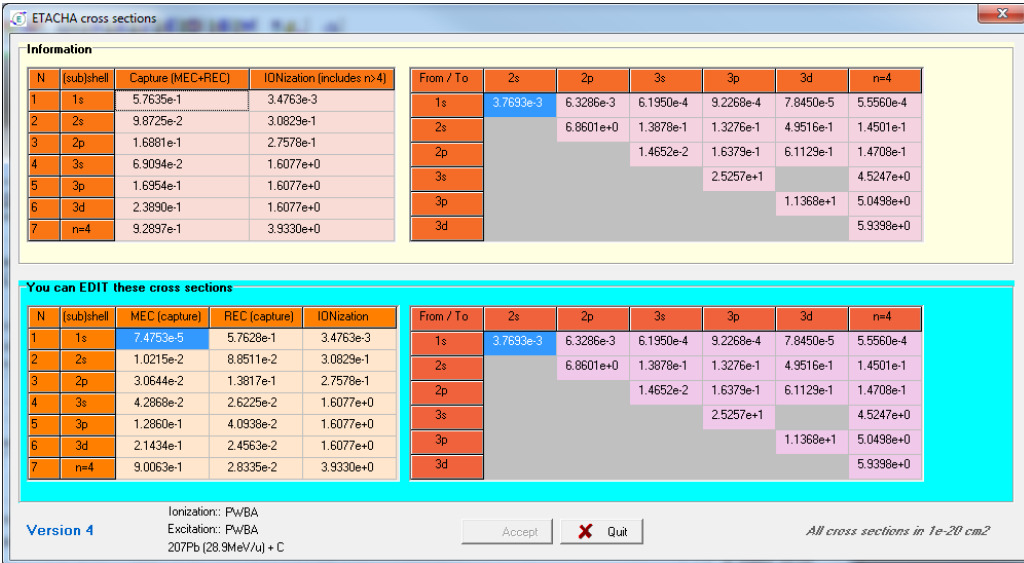
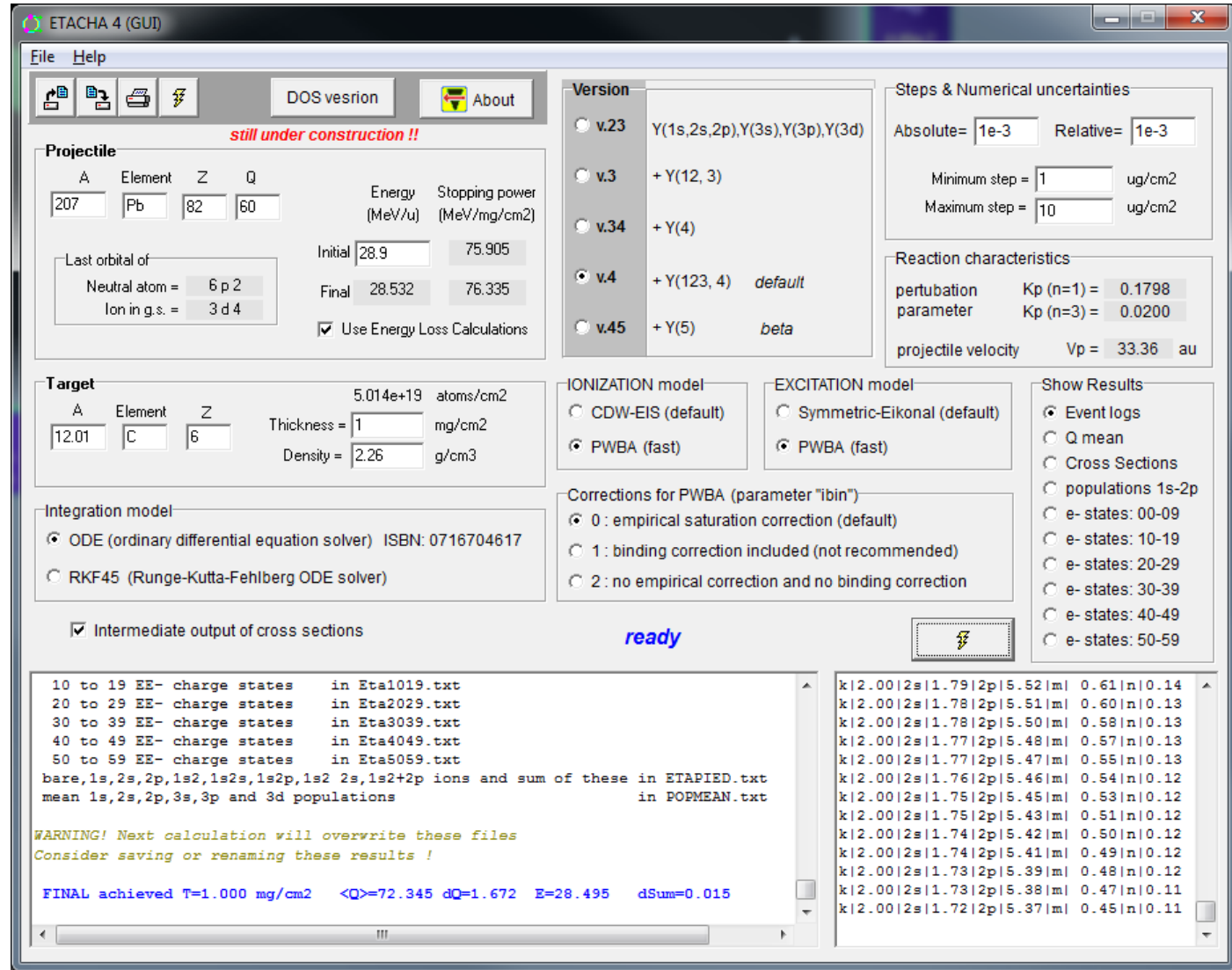
1. The current ETACHA version is “DOS-window” (“terminal” window) application
2. To compile the current version you need MS Visual Studio (project) and Intel Parallel Studio XE2016 (FORTRAN)
3. Long-long manual data entry
4. The user should manually entry final energy at the exit of material





Main window

Intermediate output window of cross sections



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

- Goodies
- Calibrations
- Transmission and rate
- Optimum Target
- Optimum Target-Wedge and Wedge-Wedge configurations
- Brho scanning
- Optimum charge state combination
- Monte Carlo calculation of transmission

Calculators

- Physical calculator
- Kinematics calculator
- Evaporation calculator
- Fusion-Residue calculator
- Radiation residue calculator**
- Ion Mass calculator
- Matrix calculator
- Mathematical calculator
- Estimated error of mean

or

- About 7300 differential equations at the initialization step
- LISE++ uses the AME2012 database for experimental half-lives and internal calculation models for unknown values
- LISE++ takes into account two possible decay branches, but the Decay Branch database should be updated

DANGER HIGH RADIATION AREA AUTHORIZED PERSONNEL ONLY

CAUTION RADIATION AREA

Radiation residue calculator

Mode to implant:

- 1. One nucleus to implant. Chose manually here
- 2. List of isotopes from file to implant
- 3. Select detector to obtain the list of isotopes stopped in

Yield = Number of atoms; N of DI = Number of Different Isotopes; Final Time (FT) = Irradiation Time (IT) + Decay Time (DT)

Rate = 7.000e+02 pps

IT : Irradiation Time [sec] = 10

N of DI @ time (IT) = 45

DT : Decay Time after irradiation [sec] = 0.5

N of DI @ time (FT) = 36

Total Yield @ time (FT) = 7e+3

1D : Residues as function of time

1D : Activity as function of time

2D : Final Residues (@ TF)

Calculate Options

Out Link

Elapsed time is 00:00:06.11 or 6.11 sec

zoom

“integrators”

v.1

Integration model

- ODE (ordinary differential equation solver) ISBN: 0716704617
- RKF45 (Runge-Kutta-Fehlberg ODE solver)

Lawrence Shampine, Marilyn Gordon,
 Computer Solution of Ordinary Differential Equations:
 The Initial Value Problem,
 Freeman, 1975, ISBN: 0716704617, LC: QA372.S416.

C++ version by John Burkardt

v.2

Integration model

- ODE (ordinary differential equation solver) ISBN: 0716704617
- RKF45 (Runge-Kutta-Fehlberg ODE solver)
- Numerical Recipes: ODEINT
- Numerical Recipes: STIFF
- Numerical Recipes: STIFBS

Numerical Recipes in ANSI C++ 2.11

NUMERICAL RECIPES SOFTWARE
 P.O. Box 243, Cambridge, MA 02238 (USA)

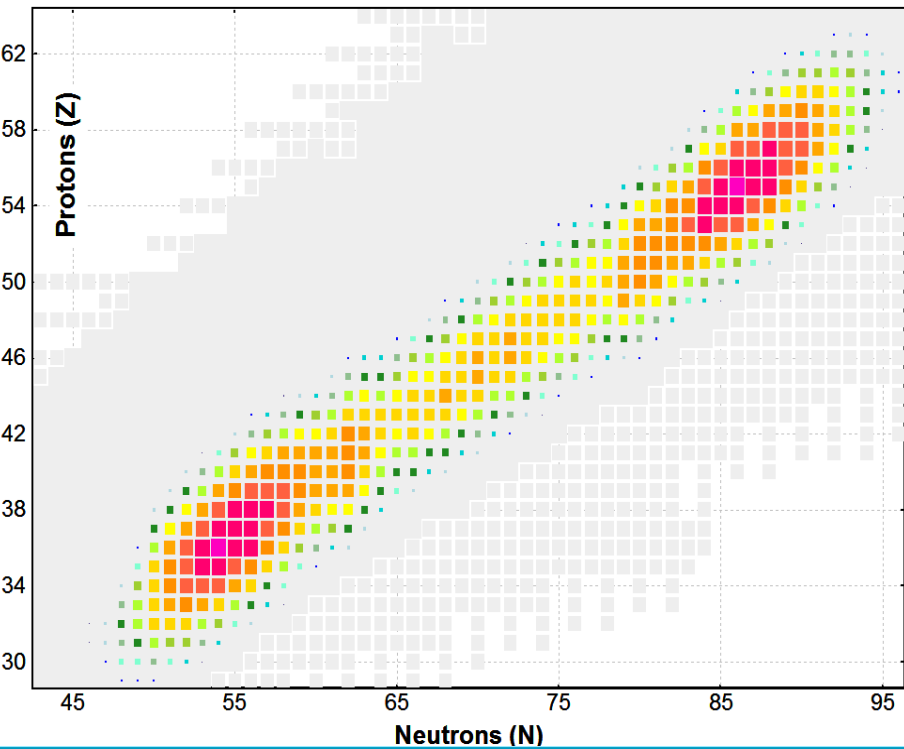
This file has been produced by LISE++ with next settings and Coulomb Fission mechanism

P rojectile	$^{238}\text{U}^{92+}$
1000 MeV/u	1 pA
F ragment	$^{130}\text{Te}^{52+}$
T arget	^{207}Pb
	1 mm
S tripper	
M aterial 1	Si
	100 nm
A Faraday Cup 1	<input checked="" type="checkbox"/>

Implanted isotopes
(number of different isotopes is 490)

[3] Total: All reactions (pps)

^{238}U (1000 MeV/u) + Pb (1 mm); Settings on ^{130}Te ; Config: MA
dp/p=100.00%
N=0-200



Radioactive decay residues

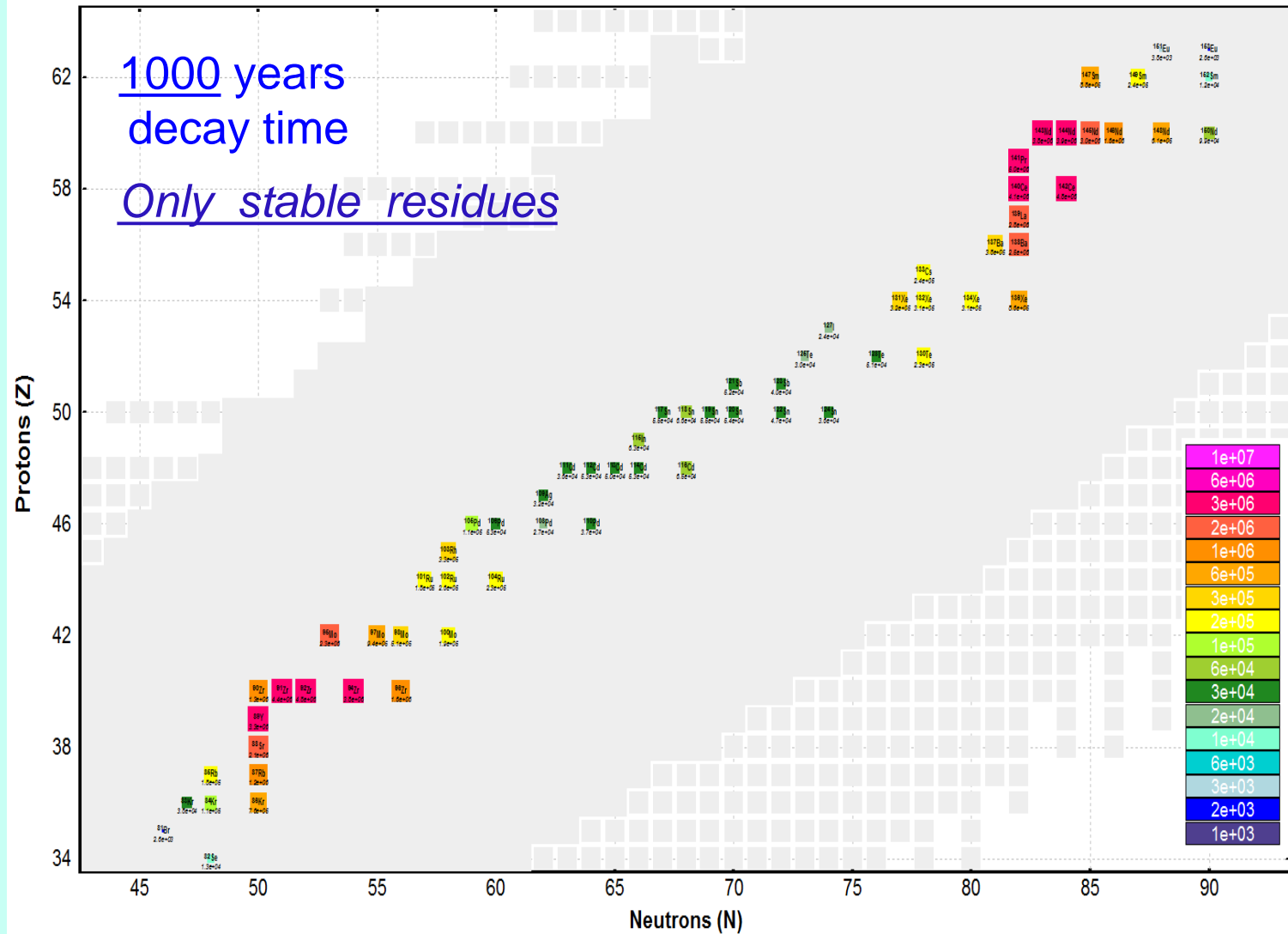
Implanted isotopes file : "G:\238U_CoulombFission.radlist" (490 isotopes)

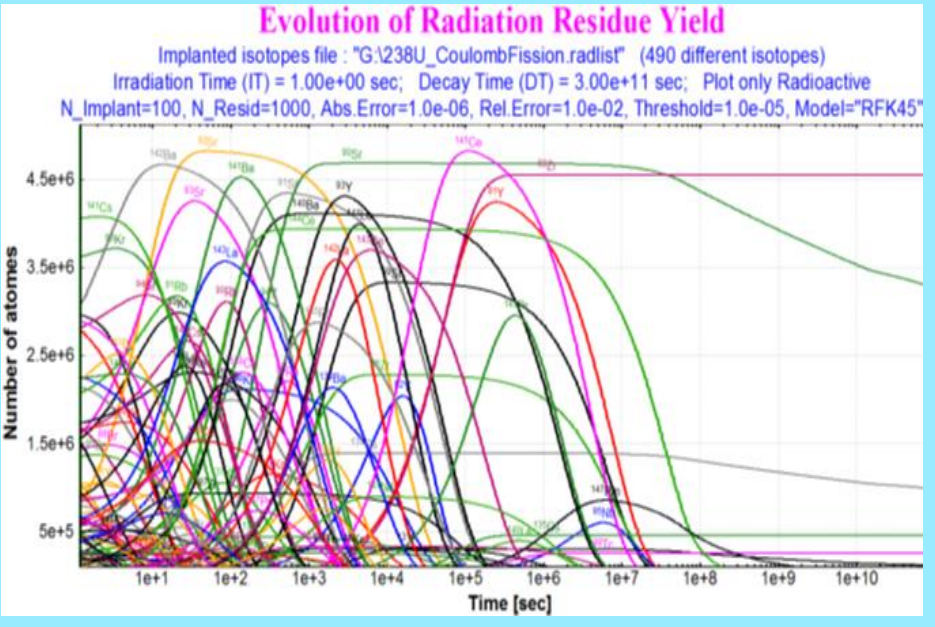
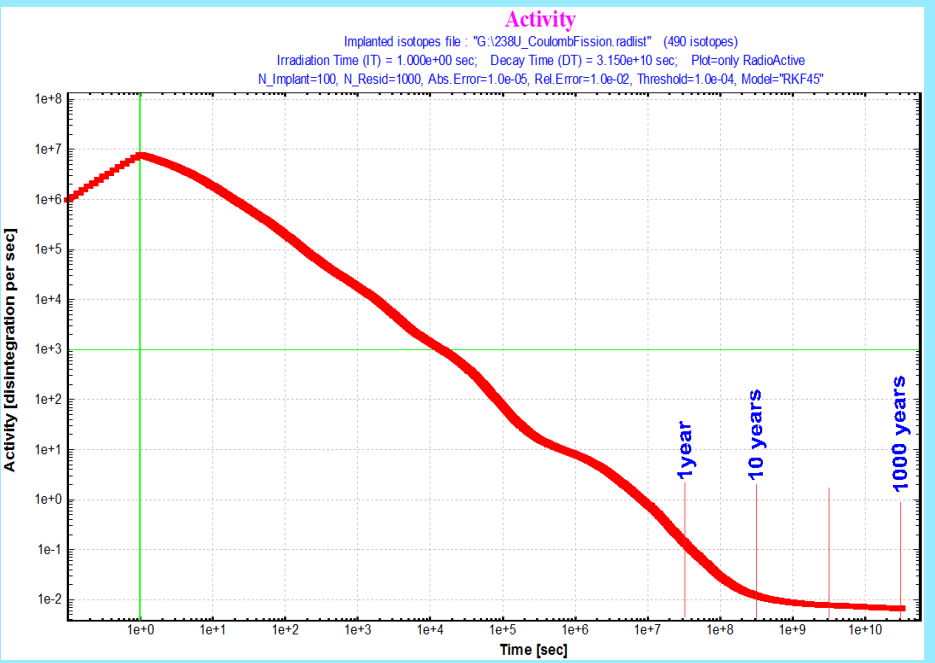
Irradiation Time (IT) = 1.000e+00 sec; Decay Time (DT) = 3.150e+10 sec

N_Implant=100, N_Resid=1000, Abs.Error=1.0e-06, Rel.Error=1.0e-03, Threshold=1.0e-05, Model="RKF45"

1000 years
decay time

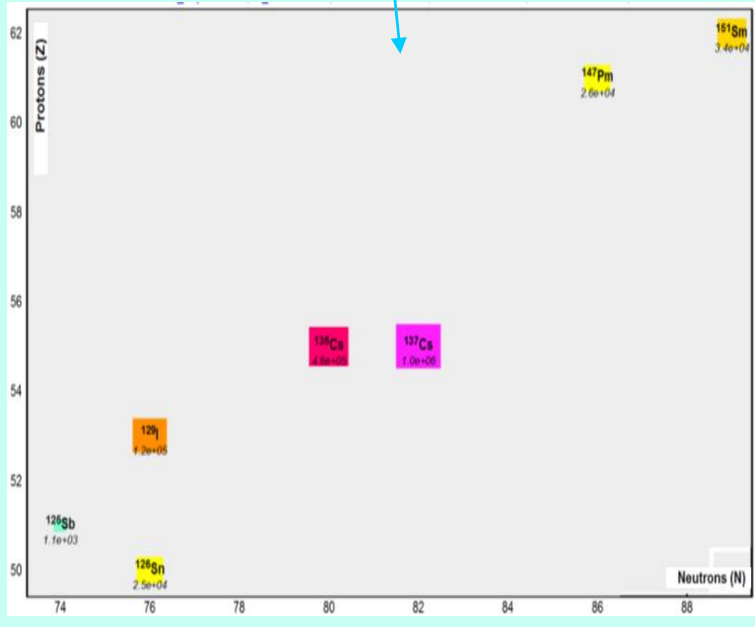
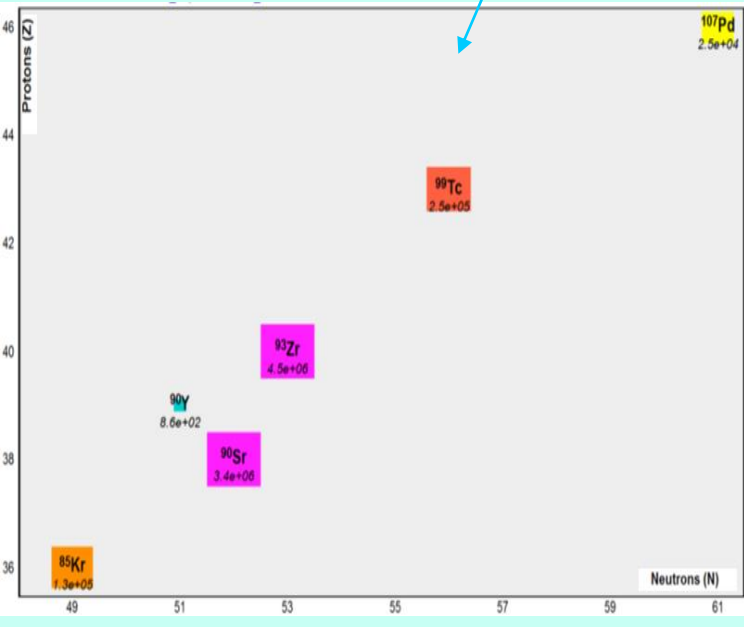
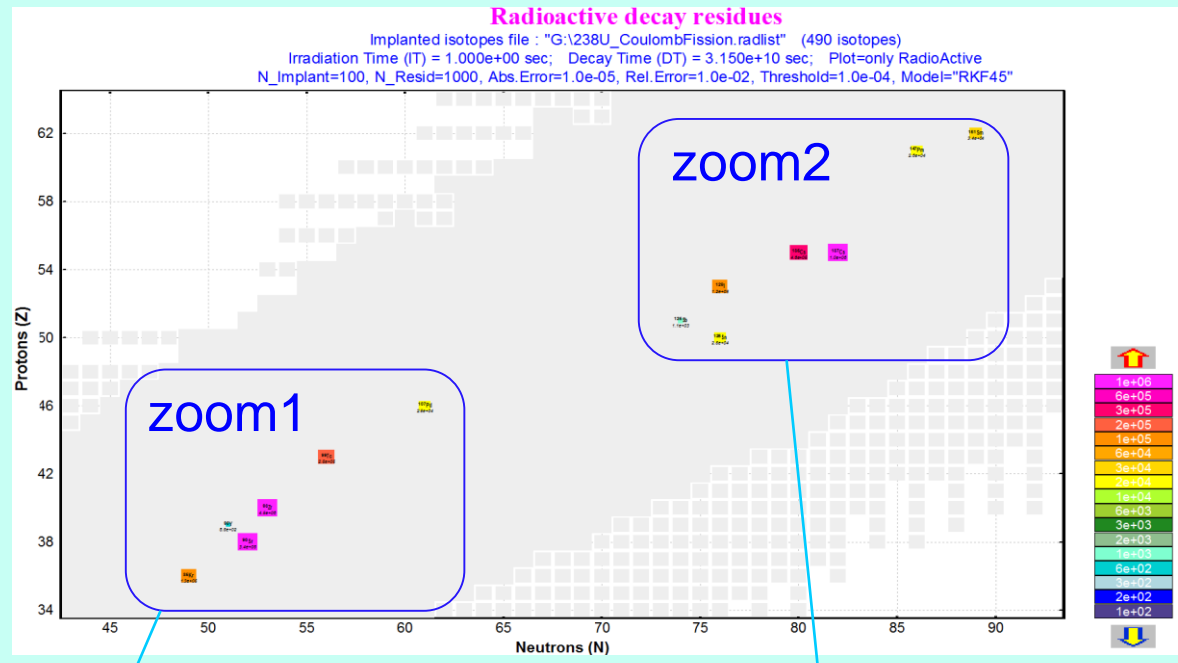
Only stable residues



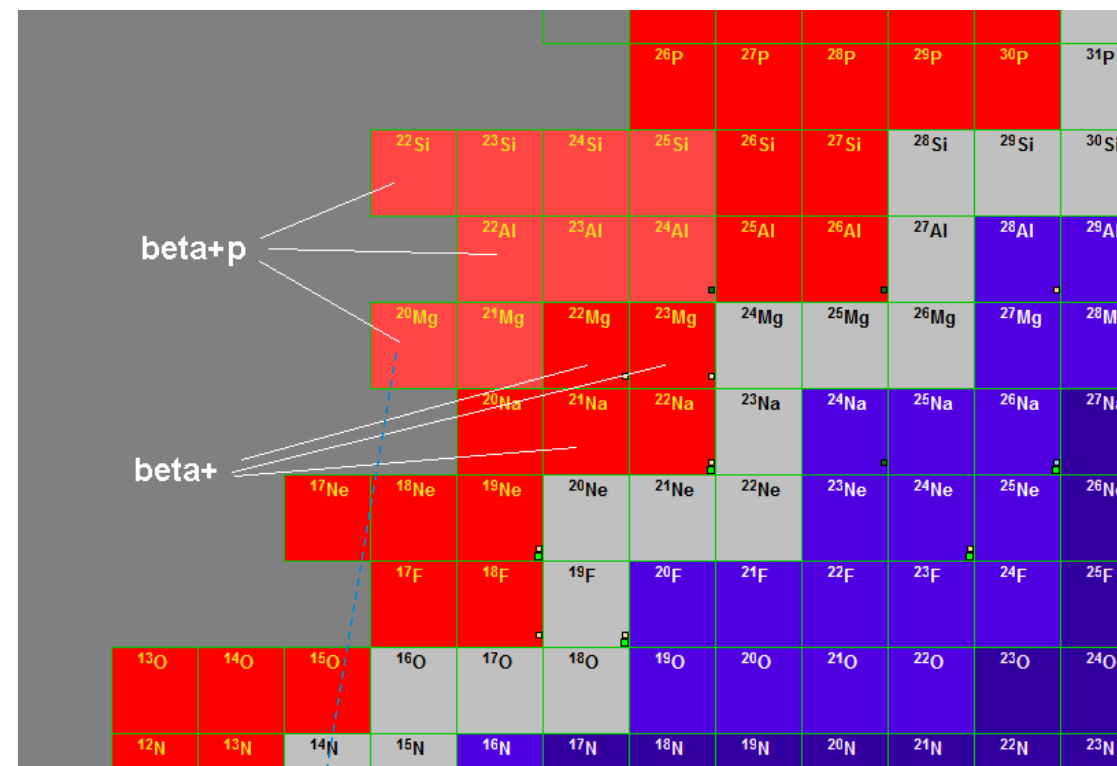
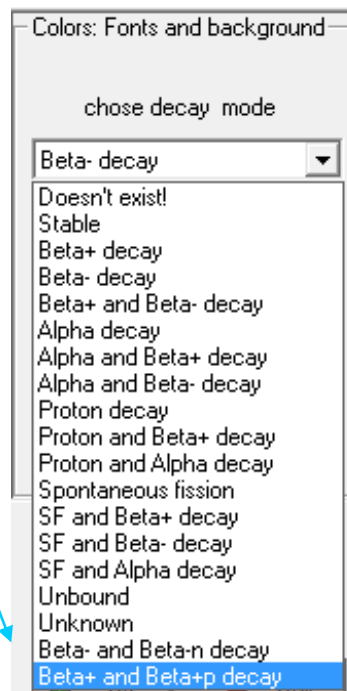


1000 years
decay time

Only
Radioactive
residues



1. Beta-Delayed Neutron Emission is new decay mode in LISE⁺⁺
2. Beta-Delayed Proton Emission is new decay mode in LISE⁺⁺
3. Decay branching ratio database
4. Editor of Decay branching ratio database
5. Using the Decay branching ratio database in Radiation Residue calculations



statistics: 20Mg

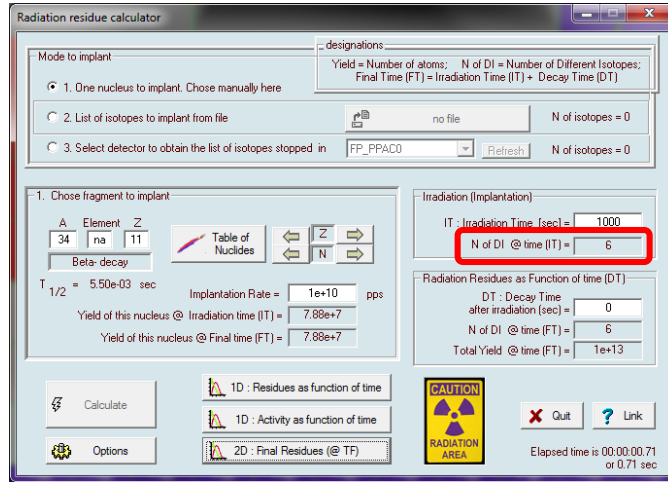
20Mg **Beta+ and Beta+p decay** (Z=12, N=8) Magnesium

AME2012 index	12008	error
Mass excess, [MeV]	17.5587	0.0270
Binding energy	134.4800	0.0270
Beta- decay	-24.5304	0.0272
Beta+ decay	10.7081	0.0270
S(2n)	*	*
S(2p)	2.3369	0.0270
Q(alpha)	-8.8524	0.0339
S(n)	22.3410	0.0568
S(p)	2.6597	0.0290
T 1/2	90 ms	6

Q-reaction (b+t -> f1+f2) -78.72 MeV (error=0.5037 MeV)

No user cross sections were found for this isotope

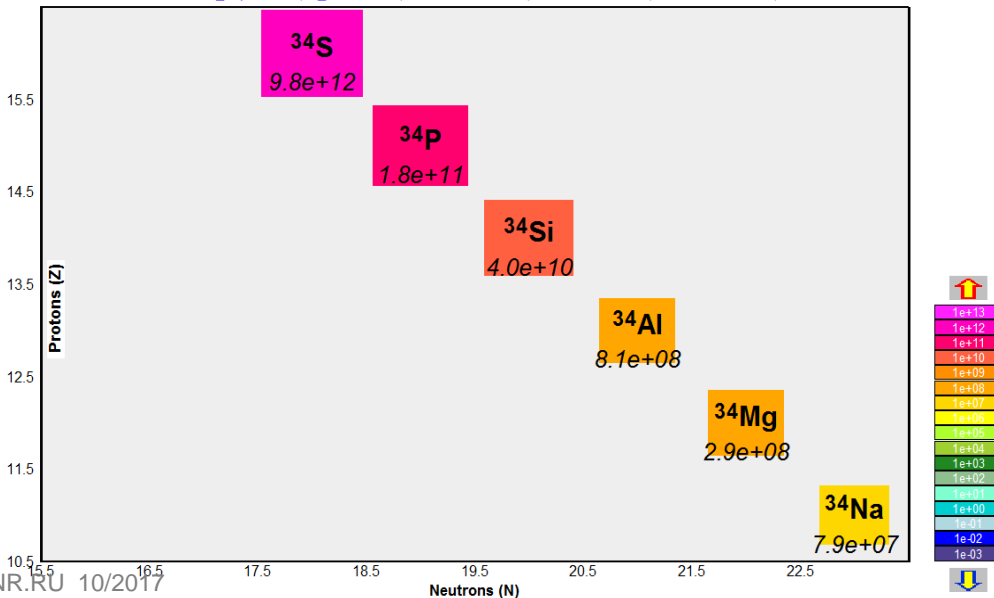
v.9.10.331. No Decay Branch Database



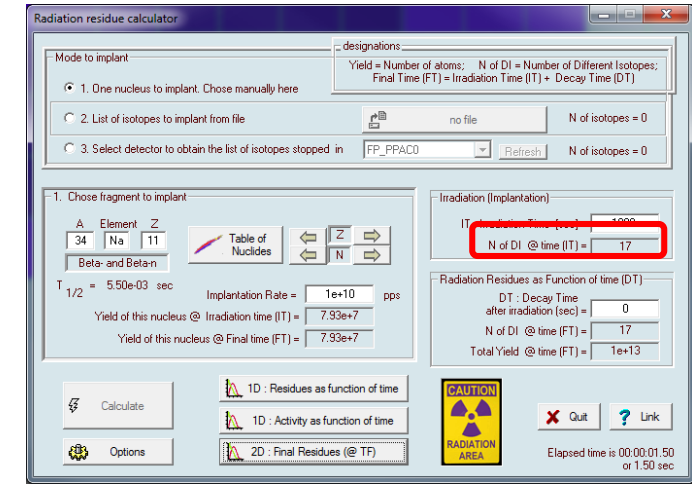
Radioactive decay residues

Initial isotope: ^{34}Na

Irradiation Time (IT) = 1.00e+03 sec; Decay Time (DT) = 1.00e-06 sec; Irr.Rate = 1.00e+10 pps; Plot All isotopes
 N_Implant=100, N_Resid=1000, Abs.Error=1.0e-11, Rel.Error=1.0e-03, Threshold=1.0e-10, Model="ODE"



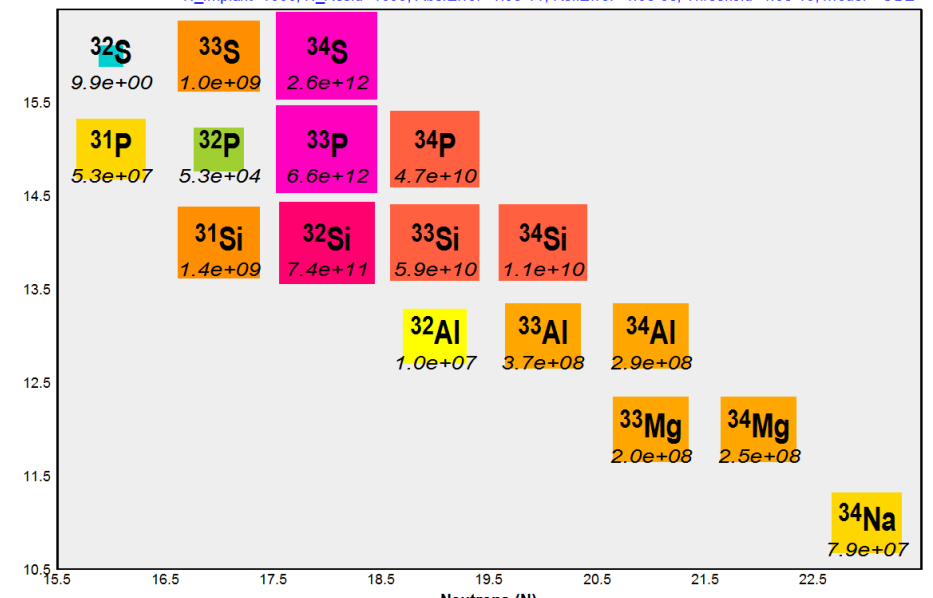
v.9.10.341. With Decay Branch Database



Radioactive decay residues

Initial isotope: ^{34}Na

Irradiation Time (IT) = 1.00e+03 sec; Decay Time (DT) = 1.00e-06 sec; Irr.Rate = 1.00e+10 pps; Plot All isotop
 N_Implant=1000, N_Resid=1000, Abs.Error=1.0e-11, Rel.Error=1.0e-03, Threshold=1.0e-10, Model="ODE"

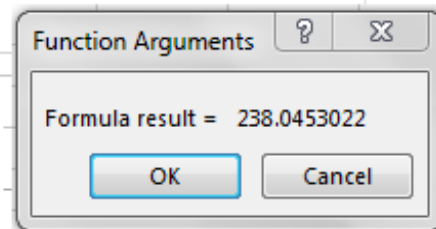


$^{238}\text{U}^{92+}$ ion mass

- v.9.8.114 atomic mass was used **238.0508 amu**
- v.9.8.117 correction for e- masses **238.0003 amu**
- v.9.10.131 correction for e- binding energies **238.0011 amu**

LISE for Excel new function

=lise.xlsm!MassIon(92,238,10)



Ion Mass Calculator / Ionisation Energy Database

A	Element	Z
238	u	92
Stable		

Table of Nuclides

Z

N

"U" ... Z = 92 ... Uranium

Shl.	Z	Q	IsoelSeq	Ground Shells	Ioniz_Energy	Total BE
7	92	0+	U	[Rn].5f3.6d.7s2	0.0062	761.513
7	92	1+	Pa	[Rn].5f3.7s2	0.0116	761.507
5	92	2+	Th	[Rn].5f4	0.0198	761.495
5	92	3+	Ac	[Rn].5f3	0.0367	761.476
5	92	4+	Ra	[Rn].5f2	0.046	761.439
5	92	5+	Fr	[Rn].5f	0.06	761.393
6	92	6+	Rn	[Hg].6p6	0.089	761.333
6	92	7+	At	[Hg].6p5	0.101	761.244
6	92	8+	Po	[Hg].6p4	0.116	761.143
6	92	9+	Bi	[Hg].6p3	0.129	761.027
6	92	10+	Pb	[Hg].6p2	0.158	760.898
6	92	11+	Tl	[Hg].6p	0.173	760.740
6	92	12+	Hg	[Xe].4f14.5d10.6s2	0.21	760.567
6	92	13+	Au	[Xe].4f14.5d10.6s	0.227	760.357
5	92	14+	Pt	[Xe].4f14.5d10	0.323	760.130
5	92	15+	Ir	[Xe].4f14.5d9	0.348	759.807
5	92	16+	Os	[Xe].4f14.5d8	0.375	759.459
5	92	17+	Re	[Xe].4f14.5d7	0.402	759.084
5	92	18+	W	[Xe].4f14.5d6	0.431	758.682
5	92	19+	Ta	[Xe].4f14.5d5	0.458	758.251
5	92	20+	Hf	[Xe].4f14.5d4	0.497	757.793
5	92	21+	Lu	[Xe].4f14.5d3	0.525	757.296
5	92	22+	Yb	[Xe].4f14.5d2	0.557	756.771
5	92	23+	Tm	[Xe].4f14.5d	0.585	756.214
4	92	24+	Er	[Xe].4f14	0.73	755.629
5	92	25+	Ho	[Cd].4f14.5p5	0.77	754.899
5	92	26+	Dy	[Cd].4f14.5p4	0.8	754.129
5	92	27+	Tb	[Cd].4f14.5p3	0.84	753.329
5	92	28+	Gd	[Cd].4f14.5p2	0.93	752.489

Atom & Ion Masses

Charge State	Ground shell configuration	Total binding energy (keV)	Mass	
			amu	GeV
Q=0 atom	[Rn].5f3.6d.7s2	761.513	238.05079	221.742896
Q= 7	[Hg].6p5	761.244	238.04695	221.739319
Q=Z full stripped		0.000	238.00114	221.696645

Comments

Ionization energies are taken from the NIST Atomic Spectra Database <http://www.nist.gov/pml/data/asd.cfm> with in-house extrapolation for heavy ions. Their configurations are marked by the symbol "?". The database range is 1 <= Z <= 110. For heavier ions no electron binding corrections. Binding energies are determined by summing up all relevant ionization energies.

$M(A,Z,Q) = M(A,Z) \cdot Q \cdot M_e + TBE(0) - TBE(Q)$

IsoelSeq -- Isoelectronic sequence

Ground Shells -- Ground-state electronic shells

Ioniz_Energy -- Ionization energy [keV]

Total BE -- Total binding energy [keV]

Designations used in the ground shell lists:

[Ne] = 1s2.2s2.2p6

[Ar] = [Ne].3s2.3p6

[Kr] = [Ar].3d10.4s2.4p6

[Cd] = [Kr].4d10.5s2

[Xe] = [Cd].5p6

[Hg] = [Xe].4f14.5d10.6s2

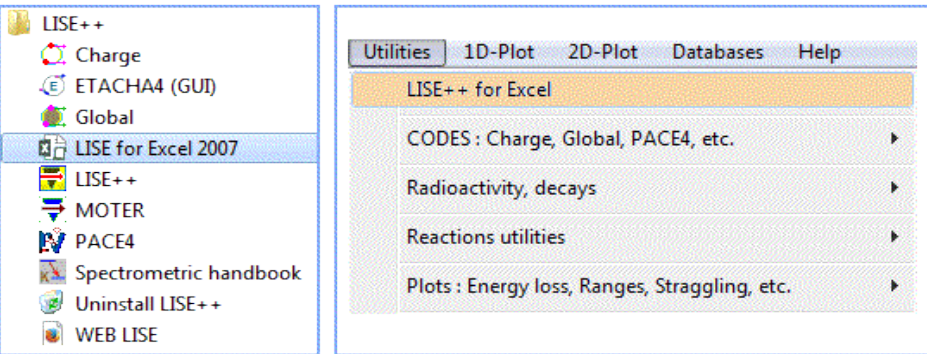
[Rn] = [Hg].6p6

Link Quit

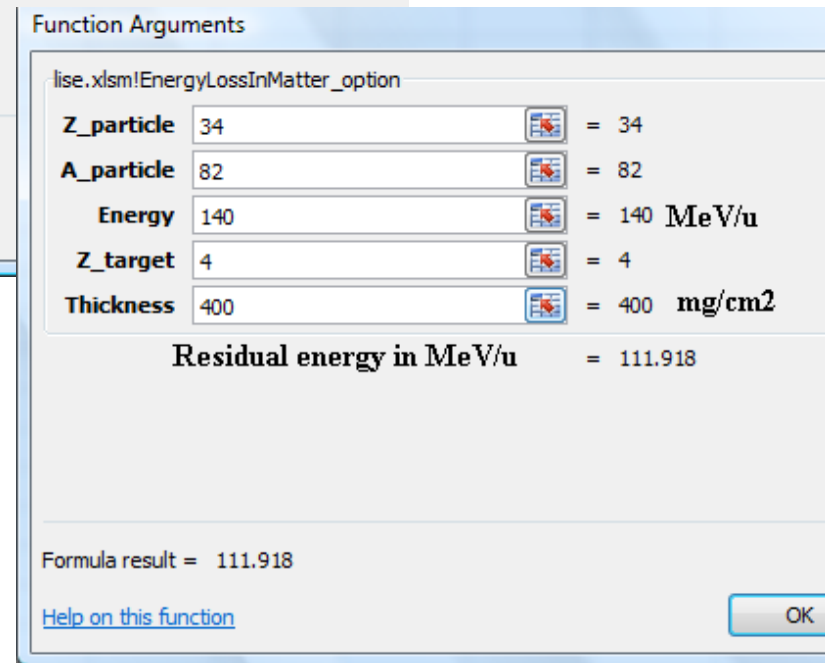
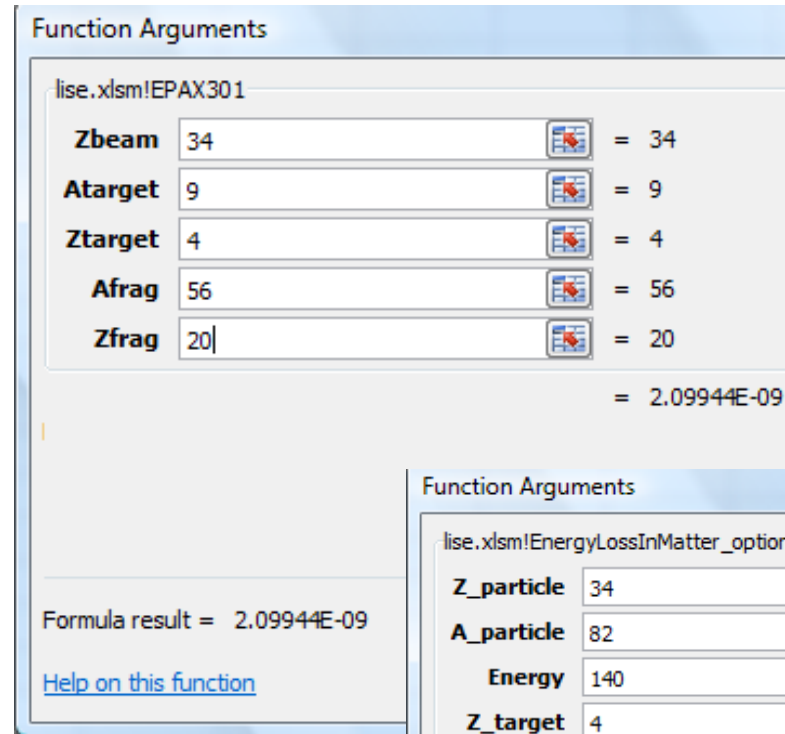
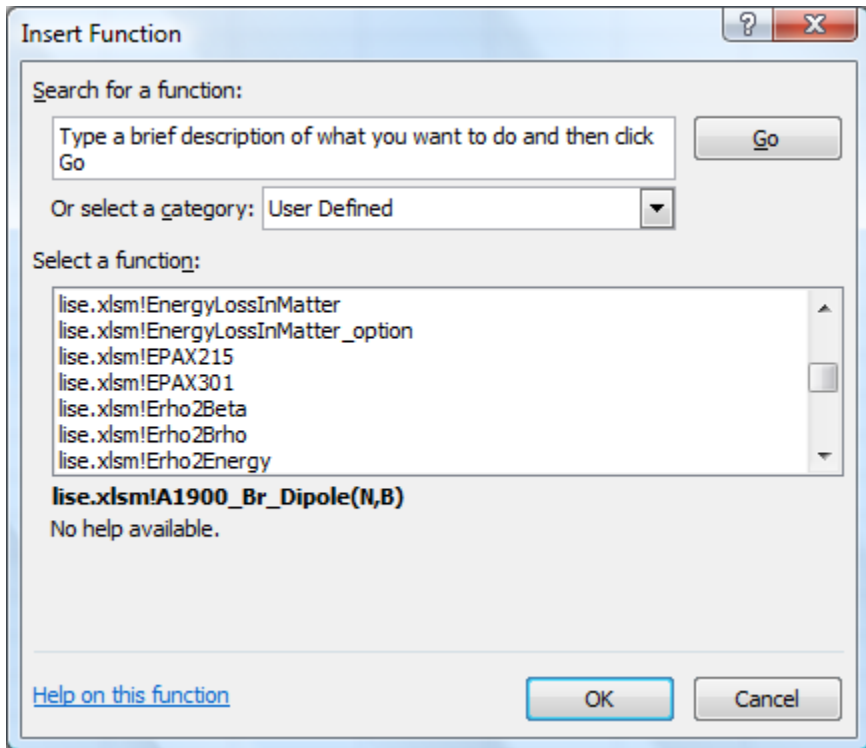
The opportunity of using the LISE⁺⁺ computing package by other programs has appeared with implementation of dynamical libraries (LISE_atima.dll, LISE_Global.dll, LISE_loss.dll, and others) in the package. Some subroutines were moved from the LISE.exe main module to separate libraries (*.DLL), and can be executed from these libraries by other programs.

The modules of calculation of energy losses in matter, range in materials, straggling of range and energy losses, and also empirical parameterizations of cross sections (EPAX 2.15, EPAX 3.01) are available to be used for calculations in MS Excel through the LISE_xls.dll library. It is necessary to notice, that such opportunity exists only for the versions of the program LISE⁺⁺ installed in a standard way, instead of taken from the "open version" directory. The libraries are placed by the installer to the directory "windows/system" ("windows/system32").

The LISE.XLSM is located in the LISE⁺⁺ root directory, and its icon is available from the LISE⁺⁺ folder (see Fig.1, left panel). Alternatively it is possible to run LISE.xlsm from the LISE⁺⁺ code menu (see Fig.1, right panel).

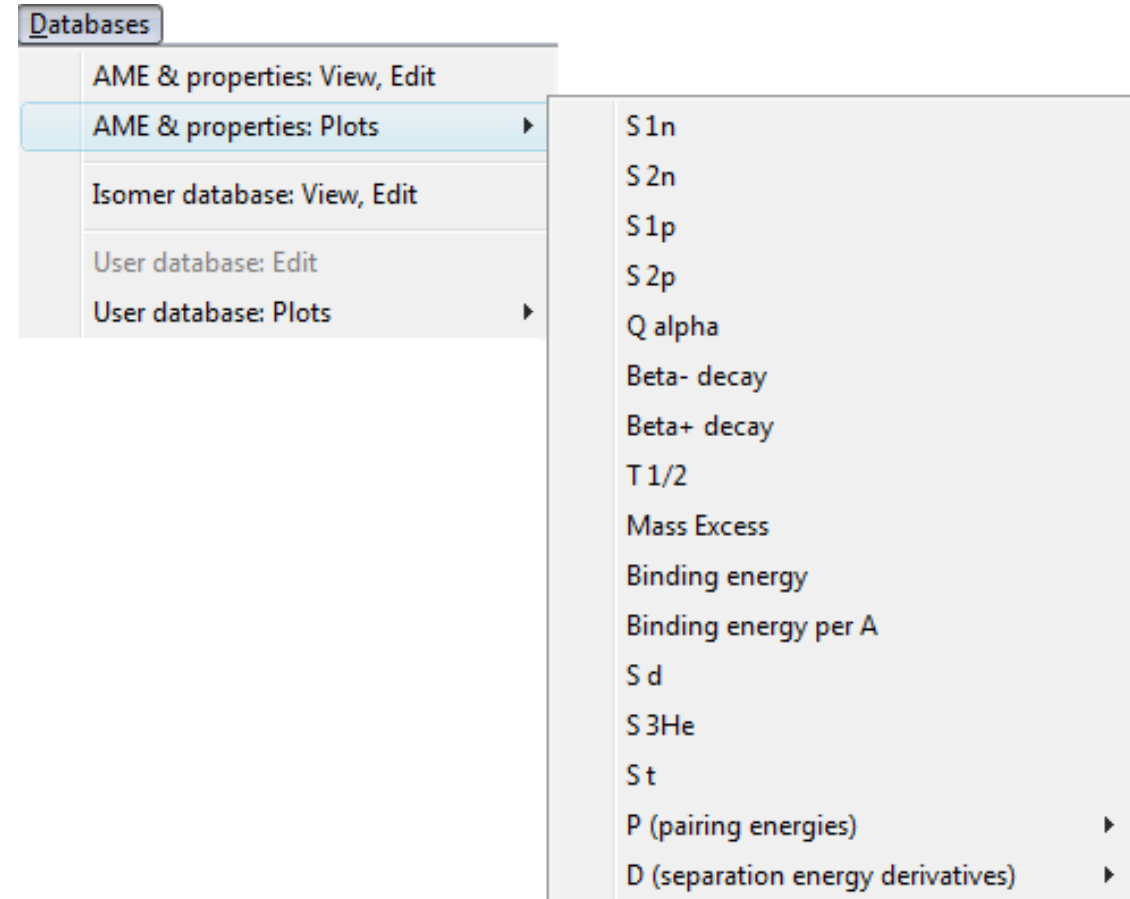
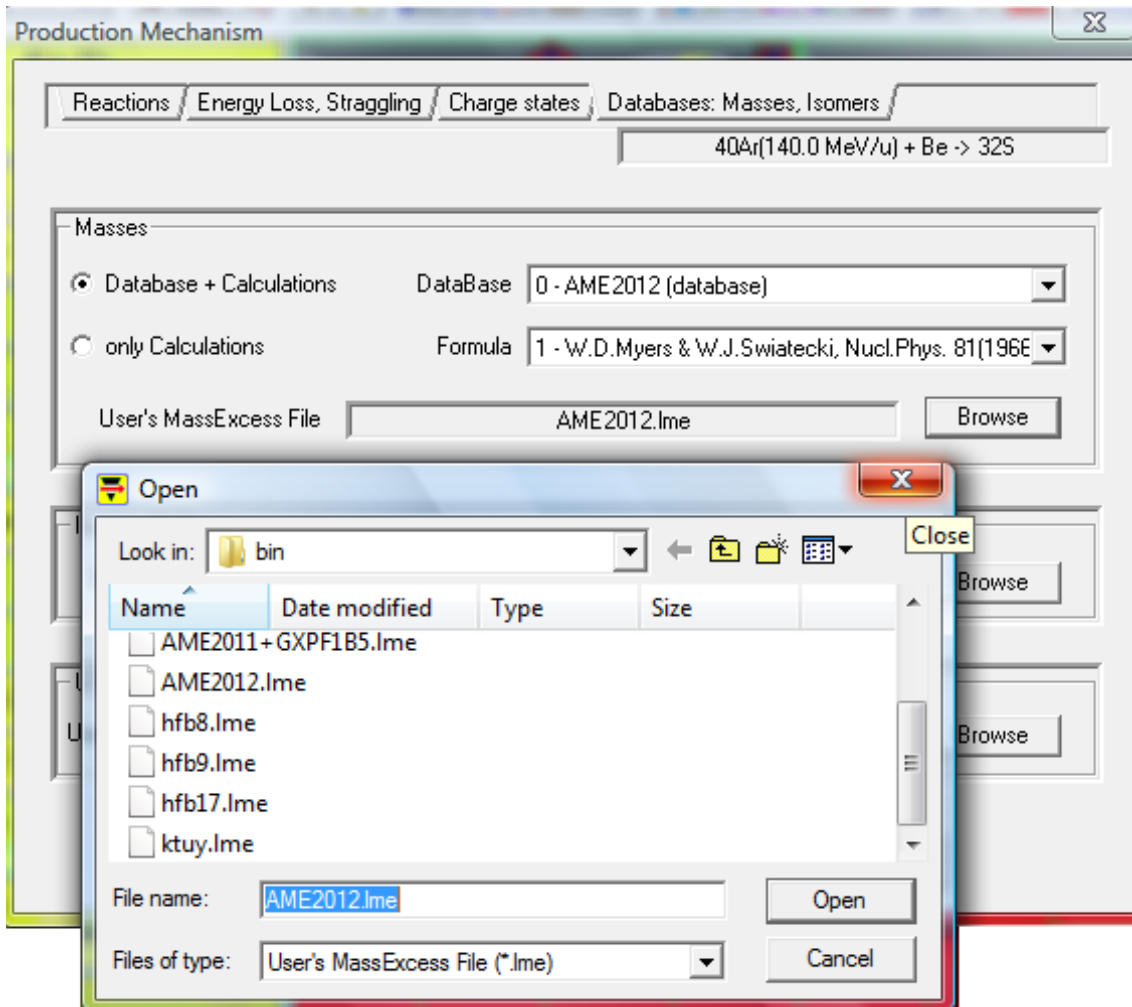


Energy loss calculation method	Charge State calculation methods	Energy Straggling calculation methods	names	
<input type="button" value="0 - Hubert"/> <input type="button" value="1 - Ziegler"/> <input type="button" value="2 - ATIMA"/>	<input type="button" value="0 - Winger"/> <input type="button" value="1 - Leon"/> <input type="button" value="2 - Shima"/> <input type="button" value="3 - Global+Winger"/> <input type="button" value="4 - Global+Leon"/> <input type="button" value="5 - Schiwietz (solid)"/>	<input type="button" value="0 - Anne"/> <input type="button" value="1 - ATIMA"/>	Zparticle= 92 Aparticle= 238 Ztarget= 4 Atarget= 9 Energy= 100 Thickness= 5 ZmQ= 1	MeV/u mg/cm2
current state = 2	current state = 3	current state = 1	you may change	
Energy After Matter with option	Residual energy in MeV/u	Zparticle, Aparticle Energy [MeV/u], Ztarget Thickness [mg/cm2], option	99.05	MeV/u
Range In Matter	Range in mg/cm2	Zparticle, Aparticle Energy [MeV/u] Ztarget	337.57	mg/cm2
Range In Matter with option	Range in mg/cm2	Zparticle, Aparticle Energy [MeV/u] Ztarget, option	369.62	mg/cm2
StragglingEnergy	energy straggling in material [MeV/u]	Zparticle, Aparticle Energy [MeV/u] Ztarget, Thickness [mg/cm2]	0.009	MeV/u
StragglingRange	range straggling in material [mg/cm2]	Zparticle, Aparticle Energy [MeV/u] Ztarget	0.279	mg/cm2
Stopping power	Hubert - option=0	Zparticle, Aparticle Energy [MeV/u] Ztarget	44.95945	MeV/(mg/cm2)



1 **A1900_Br_Dipole** (N of dipole,B_field)
 2 **A1900_R_Dipole** (N of dipole,B_field)
 3 **Beta2Brho** (beta, Mass, Q)
 4 **Beta2Energy** (beta)
 5 **Beta2Gamma** (beta)
 6 **Brho2Beta** (Brho, mass, Q)
 7 **Brho2Energy** (Brho, Mass, q)
 8 **Brho2Momentum** (Brho, q)
 9 **BrhoEnergy2Q** (Brho, Energy, Mass)
 10 **Charge_dQ** (Energy, Z_particle, Z_target, Option)
 11 **Charge_Qmean** (Energy, Z_particle, Z_target, Option)
 12 **ChargeState** (Energy, Z_particle, Z_target, Z-q)
 13 **ChargeState_option** (Energy, Z_particle, Z_target, Z-q, Option)
 14 **Energy2Beta** (Energy)
 15 **Energy2Brho** (Energy, Mass, Q)
 16 **Energy2Gamma** (Energy)
 17 **Energy2Momentum** (Energy, Mass)
 18 **EnergyLossInMatter** (Z_particle, A_particle, Energy, Z_target , Thickness (mg/cm2))
 19 **EnergyLossInMatter_option** (Z_particle, A_particle, Energy, Z_target , Thick (mg/cm2), Option)
 20 **EPAX215** (Abeam, Zbeam, Atarget, Ztarget, Afrag, Zfrag)
 21 **EPAX301** (Abeam, Zbeam, Atarget, Ztarget, Afrag, Zfrag)
 22 **Erho2Beta** (Erho, Mass,Q)
 23 **Erho2Brho** (Erho, Mass,Q)
 24 **Erho2Energy** (Erho, Mass,Q)
 25 **Find_Line** (x1, y1, x2, y2, X)
 26 **Find_Parabola** (x1, y1, x2, y2, x3, y3, X)
 27 **Gamma2Beta** (gamma)
 28 **Gamma2Energy** (gamma)
 29 **GlobalCode** ([Z-q]_out, Ab, Zb, [Z-q]_in, Energy, At, Zt, Thick (mg/cm2), Option, Fast)
 30 **Interpolate2** (X_array, Y_array, X)
 31 **Interpolate3** (X_array, Y_array, X)
 32 **Mass** (Z)
 33 **Masslon** (Z, A, q)
 34 **Masslotope** (Z, A)

35 **MatricesMult** (Matrix1, Matrix2, Row, Column)
 36 **Matrix2OrderVectorMult**(Matrix, Vector)
 37 **MatrixElement** (Matrix, Row, Column)
 38 **MatrixVectorMult** (Matrix, Vector, Row)
 39 **MatrixVectorSumSquare** (Matrix, Vector, Row)
 40 **Mg2Mkm** (ThickMg, Z)
 41 **Mkm2Mg** (ThickMkm, Z)
 42 **Momentum2Brho** (Momentum, Q)
 43 **Momentum2Energy** (Momentum, Mass)
 44 **MyGauss** (X, X_mean, Sigma)
 45 **MyGaussAsym** (X, X_peak, Sigma, Asymmetry)
 46 **NumberEvents** (A_target, CS (mb), Flux , TargetThickness (mg/cm2))
 47 **RangeInMatter** (Zparticle, Aparticle, Energy, Ztarget)
 48 **RangeInMatter_optioun** (Zparticle, Aparticle, Energy, Ztarget, Range_option)
 49 **S_Accident** (Average, Sigma)
 50 **S_AreaXY** (X_array, Y_array)
 51 **S_AreaXYwithError** (X_array, Y_array, Yerror_array, Ref [0-Area/1-dArea])
 52 **S_AssymXY** (Xmean(XY), Sigma(XY), X_array, Y_array)
 53 **S_AverageXwithError** (X_array, Xerror_array, Ref [0-Area/1-dArea])
 54 **S_AverageXY** (X_array, Y_array)
 55 **S_AverageXY_Error** (X_array, Y_array)
 56 **S_AverageXY_Error_instr** (X_array, Y_array, Error_array)
 57 **S_chi_sq** (Experimental value, Calculated value)
 58 **S_chi_sq_sum** (Experimental array, Calculated array)
 59 **S_rounded_rectangle** (X, left Boundary, Right Boundary, Sigma)
 60 **S_SigmaXY** (XmeanXY, X_array, Y_array)
 61 **S_SigmaXY_error** (X_array, Y_array)
 62 **S_SigmaXY_Error_instr** (X_array, Y_array, E_array)
 63 **SchiwietzGas** (Energy, Z_particle, Z_target, Z-q)
 64 **Show_Element** (Z_element)
 65 **Show_Z** (Name of element)
 66 **ShowOption** (Option)
 67 **StoppingPower** (Z_particle, A_particle, Energy, Z_target, Option)
 68 **StragglEnergy** (Z_particle, A_particle, Energy, Z_target, Thickness)
 69 **StragglRange** (Z_particle, A_particle, Energy, Z_target)



Databases

DataBase: 0 - AME2012 (database)

A: 35 Element: S Z: 16 N: 19

Beta- decay

Database Index: 16019

T_{1/2}: 87.37 d
dT_{1/2}: 0.04

	Value	Error	
Mass Excess	-28.8462		MeV
Binding Energy	298.8265	0.0000	MeV
Beta- decay	0.1673	0.0000	MeV
Beta+ decay	-3.9884	0.0019	MeV
S 2n	18.4030	0.0000	MeV
S 2p	22.9098	0.0007	MeV
Q alpha	-8.3221	0.0001	MeV
S 1n	6.9858	0.0000	MeV
S 1p	11.5865	0.0008	MeV

Put "*" into a cell If value is unknown

Half-life (sec): Experimental (database): 7.55e+06

Calculation: beta decay: 3.99e+10, alpha decay: , proton emission:

Buttons: Discovery, Save, Quit, calculations, Add Record, Delete Record, Show Structure, 263

Isomer Database

A: 38 Element: K Z: 19 N: 19

Beta+ decay

for this isotope

Current isomeric gamma ray: 1 8 Total number of isomer gamma rays

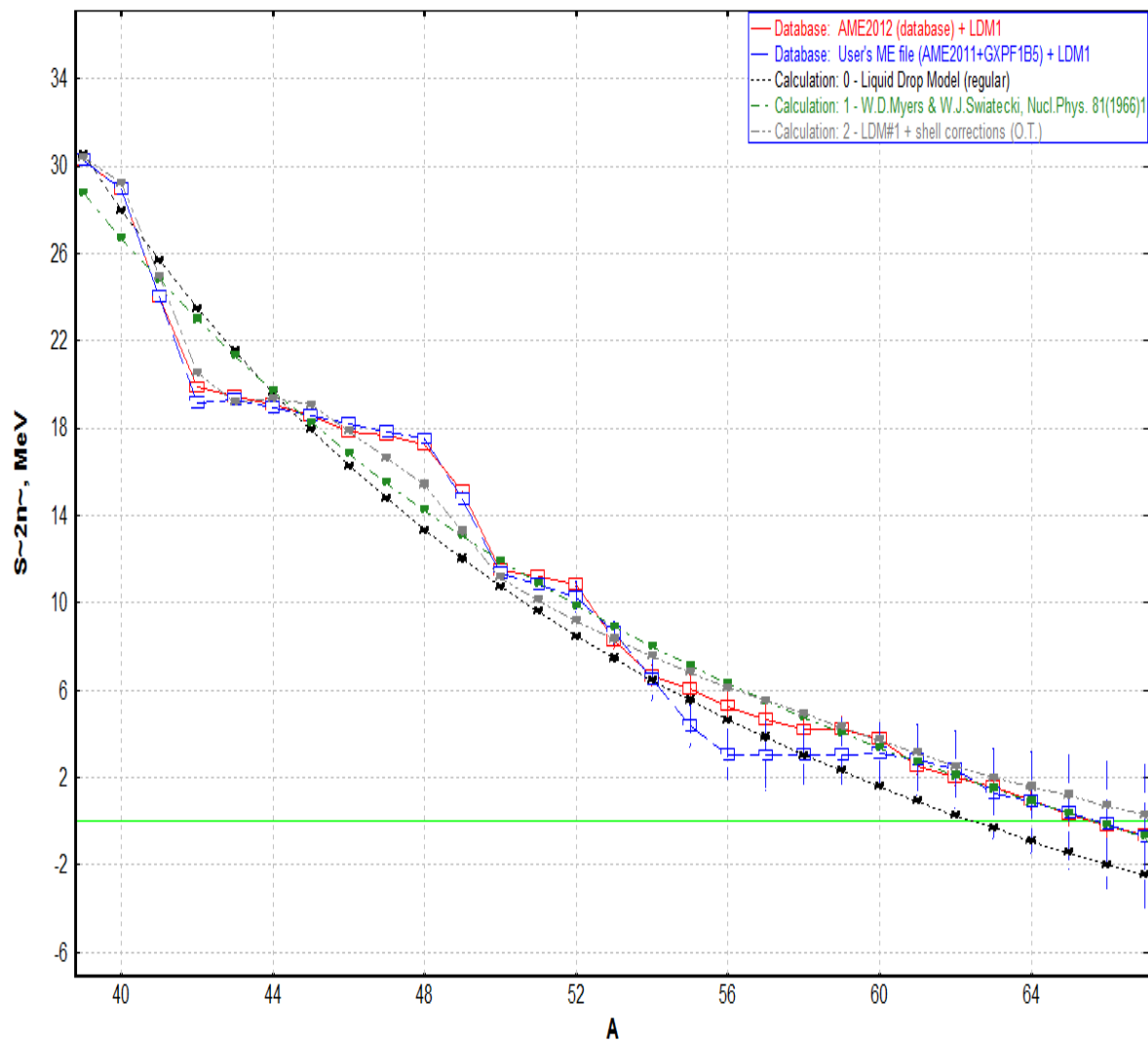
Database Index: 38190037

	Value	Error	
Gamma energy	37.8	AP	keV
Isomeric ratio (level population)	10	AP	%
T 1/2	2.198E+1	1.10E+1	micro-second
Level energy	3458.	2.	keV
J pi	7+.(5+)		
I gamma	100.	11.	%
M gamma	E1(+M2)		
M ratio	0.	13.	
Conversion Coef.	0.4	0.6	
Data source	NNDC		

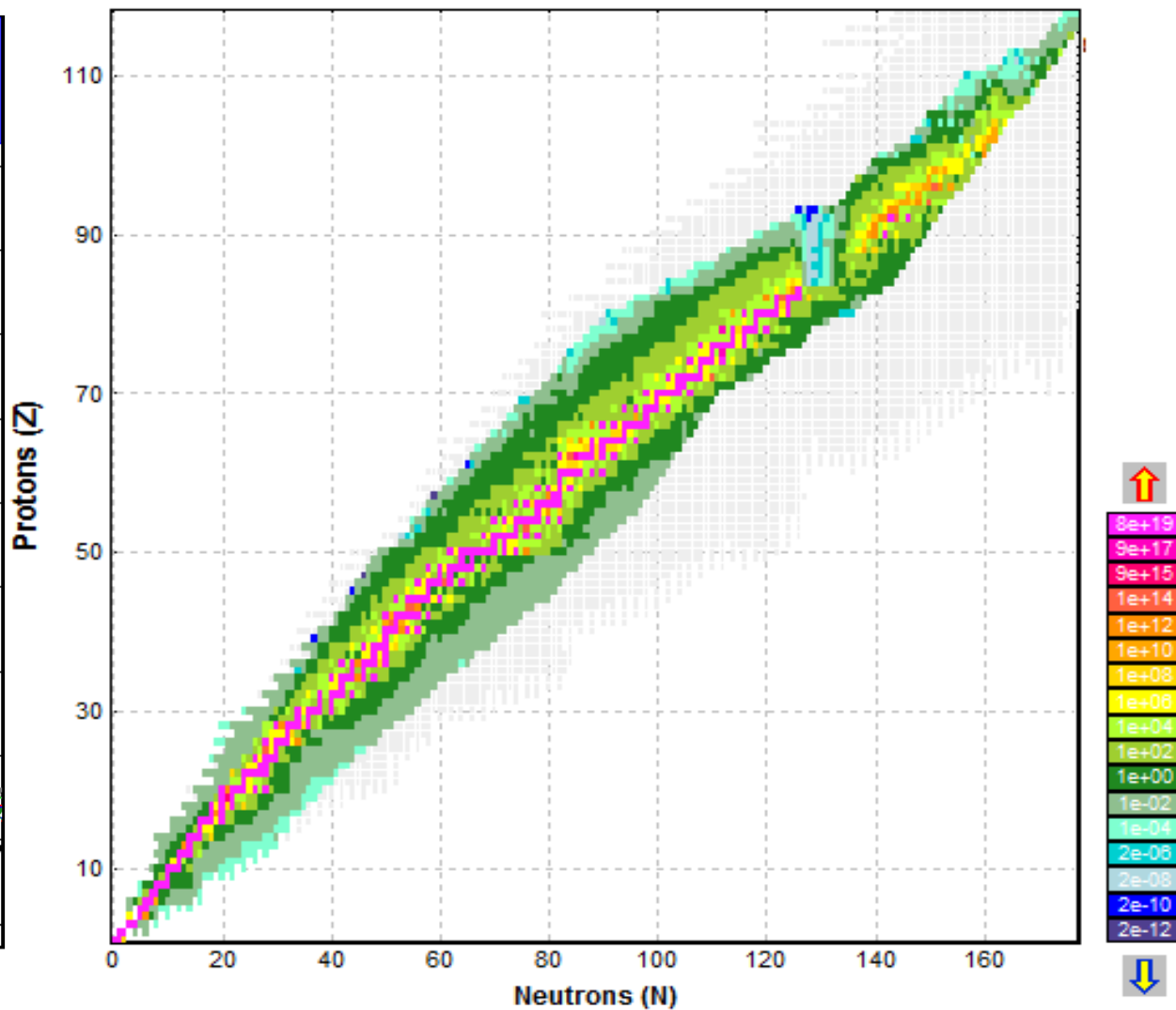
User Name: OT

Buttons: Save, Quit, Help, Add Record, Delete Record, Show Structure, 21

S_{2n}
 <All methods>
 Z=20



$T_{1/2}$ (sec) (compilation)
 <Experiment+Notes>
 N=0-200



http://lise.nsl.msui.edu/doc/foil/part1_foil_lifetime_v_8_3_6.pdf

http://lise.nsl.msui.edu/doc/foil/part2_foil_lifetime_v_8_3_13.pdf

http://lise.nsl.msui.edu/doc/foil/part3_foil_lifetime_v_9_2_38.pdf

Calculation of the lifetimes of thin stripper targets

Set-up

Beam: 24Mg, Energy: 170.0 MeV/u, Intensity: 1560 pA

Foil: 9Be, Thickness: 1 g/cm²

Material properties

Initial temperature = 293 K, epsilon = 0.8, target's atom displacement energy = 25 eV

$time = k_1 \cdot K_a^{-5/4} \exp(-k_2/T)$

k1 = 21.6, k2 = 870

Use LISE++ k1(Z) function

k10 = 50, k11 = -0.07

Heat Capacity [J / g / K] [3]

Carbon capacity dependence from T

c = 0.502

Sublimation influence ("Pulsing beam" case [1])

alpha (eq.22 for [1]) = 8.12e+10 g K^(1/2)/sec/cm²

Mode to plot (dimension): S2 (N = 1e6) *

Rise Time (dT = +1K) = 4.79e-05 sec [a], "Plateau" (dT = -1K) = 1.53e-04 sec [b], Fall Time (dT = -1K) = 1.38e-03 sec [c]

Range to plot = 5.02e+02 sec

Height & Temperature from Time

[a] T0 = 293.0K, [b] T0 = 3608.7 K, P>0, [c] T0 = 3608.7 K, P=0

Radiation damages

Kd (atom displacement rate) = 7.55e-07 1 / cm²

Target warming up temperature = 3608.7 K [c] stationary beam

Foil lifetime due to radiation damages = 7.62e+08 sec, 2.1e+05 hour

Lifetime and Temperature from Beam Current

Flux structure

Stationary beam, Pulsing beam, Stationary beam & rotating target, Pulsing beam & rotating target

Pulse structure

Beam pulse length = 1e-2 sec, Repetition rate = 10 Hz

Rotation target options

Final reduced structure

Beam pulse length = 0.01 sec, Repetition rate = 10 Hz, Beam on-off time ratio = 10 %

Sublimation influence ("Stationary beam" [2])

alpha (eq.13 for [2]) = 7.83e+10 cm K^(1/2)/sec default 7.83e10 (C)

LISEcoef = 1.7

"Stationary beam" Foil lifetime due to sublimation = 3.51e+01 sec, 0.0097 hour

Height (time) & Lifetime (Beam Current)

Shape

2-D Gaussian, Uniform: ellipse, Uniform: rectangle

Radius from Interaction Area, Reduced beam spot radius(sigma) = 1 mm, Area (90.0%) = 14.4 mm²

Calculated beam characteristics (during the pulse)

Beam power lost (W/cm²) at the center of target (t=0) = 1.54e+04

Density of particle flux (at the center): 1e+05 W / cm², 24.8 puA / cm², 1.55e+14 pps / cm²

File: Stripper foil settings

Open, Save, LISE-doc, Articles, Quit

References

[1] S.G.Lebedev & A.S.Lebedev, PhysRev ST: A&B 11 (2008) 020401 [2] B.Gikal et al., Preprint P9-2005-110, JINR, Dubna [3] C.Liaw et al., Proceedings of the 1999 PAC, New York, p.3300

CATCHER utility

Materials #1-3 use

M	#1	.	<input type="checkbox"/>
M	#2	.	<input type="checkbox"/>
M	#3	.	<input type="checkbox"/>

Target

T

Be (2 mm)

Radius = mm

Materials #4-6 use

M	#4	.	<input type="checkbox"/>
M	#5	.	<input type="checkbox"/>
M	#6	.	<input type="checkbox"/>

Catcher

M

C (10 mm)

Radius 1 = mm

Radius 2 = mm

Set-up

Projectile

7Li (35.00 MeV/u; 1 pA)

Reaction Product

6He

#1 Distance from the source to the target block = mm

#2 Distance from the target block to the catcher = mm

Reaction

Projectile Fragmentation

Fusion -> Residual

Cross sections

LISE++ built-in for selected reaction

FILE: Excitation function (see Help)

f -- absent --

Configuration Files

current file

f catcher_origin

f Save file as

f Load file

Calculations

Mode

Reaction place

Fragment stopping place

Projectile stopping place

Options

Z & R(X,Y) Z & X

Z & R(X,Y,Z) Z & Y

X & Y

Minimum detector size to plot (mm)

⚡ Calculate

? Help

X Quit

✓ Save & Exit

Physical calculator

A: 32, Element: S, Z: 16, Q: 16
 Stable Table of Nuclides

Energy: 103.037 MeV/u, Brho: 30000 Tm, Erho: 391.815 MJ/C, P: 14390 MeV/c, p_transpt: 0.899378 GeV/c
 Energy: 102.947 AMeV, TKE: 3294.31 MeV, Velocity: 13.0427 cm/ns, Beta: 0.4350585, Gamma: 1.110615

After: Energy Remain. E-Loss

Block	Z \ Thickness	Me...	MeV	MeV	<Q>
FP_PIN	Si 470 micron	97.955	3131.8	162.49	16.00
FP_PP...	Al 2 mg/cm2	97.862	3128.9	2.951	16.00
FP_SCI	C9H10 100 mm	0	0	3128.9	0.00

after/into: Si 470 micron

Energy Remain: 97.9547 MeV/u
 Energy Loss: 162.49 MeV
 Energy Strag.(sigma): 0.05156 MeV/u
 Angular Strag.(sigma): 1.8017 mrad (plane)
 Lateral spread (sigma): 0.084642 microns
 Brho (for Q=Z): 2.9213 Tm

Equilibrium values for material "Si"

Charge State <Q>: 16
 dQ (sigma): 0.03
 Thickness: 1.2567 mg/cm2

Range and Energy Loss to: Si

Range: 1301.8 mg/cm2, dRange (sigma): 2.7805 mg/cm2
 5587.13 micron, 11.933 micron

Energy Remain.: 0.000 MeV/u
 Material thickness for energy rest: 1301.8 mg/cm2, 5587.1 micron

Calculation method of

Energy Losses: 2, Energy straggling: 1
 Charge States: 3, Angular straggling: 1

Print, Help, Quit

- Convert energy, momentum, magnetic rigidity seamlessly
- Calculate energy loss, range, angular and energy straggling
- “Backwards” modes to find energy of particles based on their energy loss or range

- Calculate two-body, elastic scattering or breakup kinematics
- Results in laboratory and center of mass systems
- Kinematics results can be exported to file

Kinematics calculator (relativistic)

Reactions

- TWO BODY reaction B (A , C) D
- SCATTERING B (A , C=A) D=B
- BREAKUP (FISSION) x (A , C D) x (gamma-emission)

Use Mott's scattering

For Kinematics Plots use energy values

- after reaction
- at entrance of detectors

Participants

		ME [MeV]	Excitation Energy	
A	Beam	24Mg	-13.93	0
B	Target	9Be	11.35	0
C *	Fragment	24Mg	-13.93	0
D *	Residual	9Be	11.35	0

$E(CM) = 1094.16 \text{ MeV}$

Beam energy = 170.0 MeV/u
Intensity = 60 pA
Target thickness = 1e-1 micron
Q-value = 0.00 MeV

Reaction takes place at the

- ENTRANCE of the target
- MIDDLE of the target
- EXIT of the target

Set-up

Search an angle in CM

- from 0 degrees and up
- from 180 degrees and down

	fragment (C)	residual (D)
R =	100 cm	100
w =	1 cm	1
h =	2 cm	2

Angle (deg) = 12.693 62.978 50 130
fragment (C) residual (D) fragment (C) residual (D)

Calculations

	LAB	CM	
Counting in monitor =	1.09e-1	1.18e-2	pps
Differential Cross Section =	1.17	0.127	0.0782 0.0782 mb/sr
Energy after reaction =	145.47	65.29	12.815 87.30 MeV/u**
Energy at the entrance of detectors =	145.47	65.29	MeV/u (** for gamma [MeV])
Maximum Angle =	22.07	90.00	deg
Solid Angle =	0.2	0.2	2.99 0.325 msr
delta Theta =	0.57	0.57	2.5 1.1 deg

Buttons: Kinematics plots, Rutherford plot, 2D fragment plot (Monte Carlo), Quit, Help, 3-body kinematics

Initial nucleus

Initial nucleus:

Excitation energy window:
 Lower = MeV gaussian
 Upper = MeV rectangle

Initial nucleus production cross-section = mb

make calculations down to Z =

Modes

Fragmentation of beam (Abrasion-Ablation)
 Excited nucleus evaporation
 Load initial conditions from file

2D-plots

Final Evap. Residue CS Decay channel analysis
 Fission channel CS Temperature
 Break-up channel CS Fission Excitation Energy

Final nucleus

A	Element	Z
81	Sr	38

Final fragment production cross-section mb

Minimum separation energy (SE) MeV

Minimum sum of (SE + deduced effective Coulomb barrier) MeV

Fission barrier at L=0 MeV

Average values
 < Ex > =
 < T > =

PARENT	1.71e+2									1.71e+2	82Sr
Decay modes	1n	1p	alpha							sum	max
DAUGHTER	1.97e-2	3.04e-2	6.15e-6							5e-2	80Rb

N° of all calculated nuclei:

Sum	1.71e+2	6.15e+1	2.69e+0							Initial 1e+3	Residues 1e+3	Fission	Break-up
-----	---------	---------	---------	--	--	--	--	--	--	-----------------	------------------	---------	----------

Output cross-section file

Output file of parent-daughter

Fission CS output file