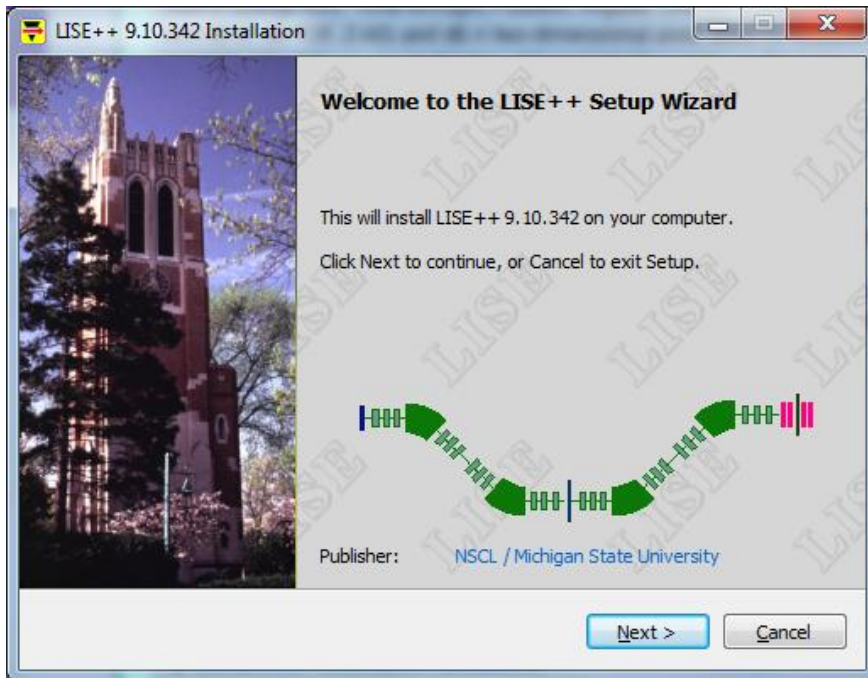




LISE⁺⁺ code : 30 years and counting

Oleg B. Tarasov (NSCL/MSU)



- Introduction
- 30 years
- Development v.9.9
- Development v.9.10.345
- Extended configurations
- LISE⁺⁺ Presentations, Statistics
- Next steps
- Porting to Qt-framework
- Summary
- Acknowledgments

LISE⁺⁺ : EXOTIC BEAM PRODUCTION WITH FRAGMENT SEPARATORS

- ❑ The LISE++ program is designed
 - to predict intensities and purities for the planning of future experiments with in-flight separators
 - to provide essential for radioactive beam tuning where its results can be quickly compared to on-line data.

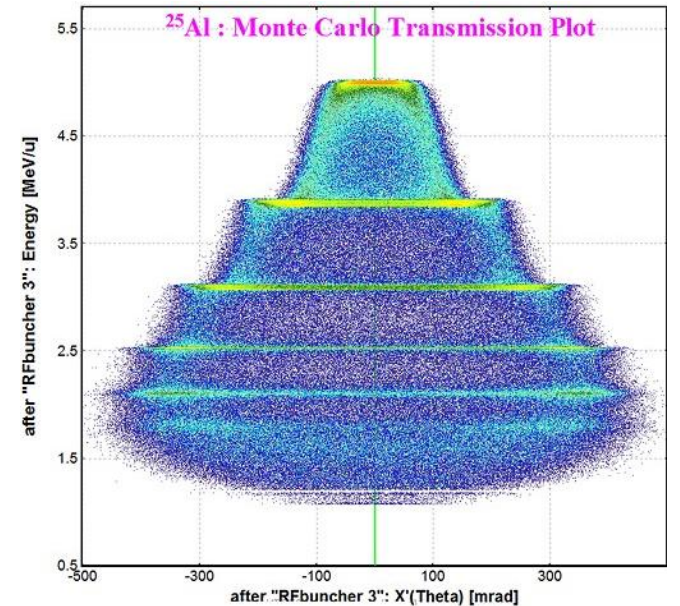
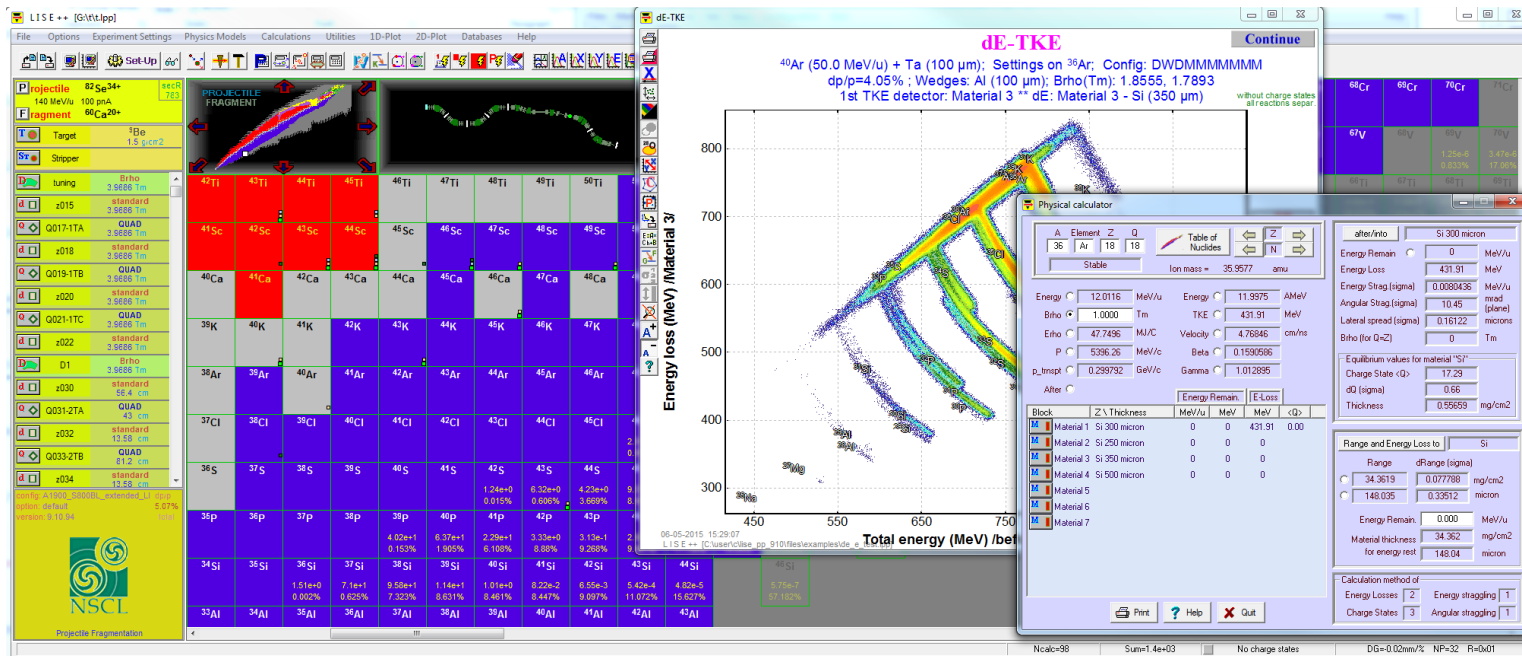
- ❑ Fragment separator construction
 - with different sections called "blocks" (magnetic and electric multipoles, solenoid, velocity filter, RF deflector and buncher, material in beam, drift, rotation element, and others).
 - is realized with a user-friendly interface that helps to seamlessly construct a fragment separator from the different blocks.

- ❑ Reaction mechanisms: Projectile Fragmentation, Fusion-Evaporation, Fusion-Fission, Coulomb Fission, and Abrasion-Fission models

- ❑ Includes configurations of separators at NSCL/MSU, RIKEN, GANIL, GSI, FLNR/JINR, TAMU, TRIUMF, Argonne and others.

- ❑ The LISE++ includes a lot of built-in powerful tools: Physical Calculator, Relativistic Kinematics Calculator, Radiation Residue Calculator, Evaporation Calculator, Nuclide, Isomeric state, Ionization Databases utilities, ISOL catcher and others

- ❑ The LISE++ package also includes codes PACE4, Global, Charge, Spectroscopic calculator, MOTER, ETACHA



30
YEARS



GANIL GRAND ACCELERATEUR NATIONAL D'IONS LOURDS

1986-1990
D.Bazin, GANIL
v.1.0-1.*

The program LISE is designed to predict intensities and purities for the planning of future experiments using radioactive beams with in-flight separators, as well as for tuning experiments where its results can be quickly compared to on-line data.

An application of transport integral ¹⁾ lies in the basis of fast calculations of the program for the estimation of temporary evolution of phase space distributions.

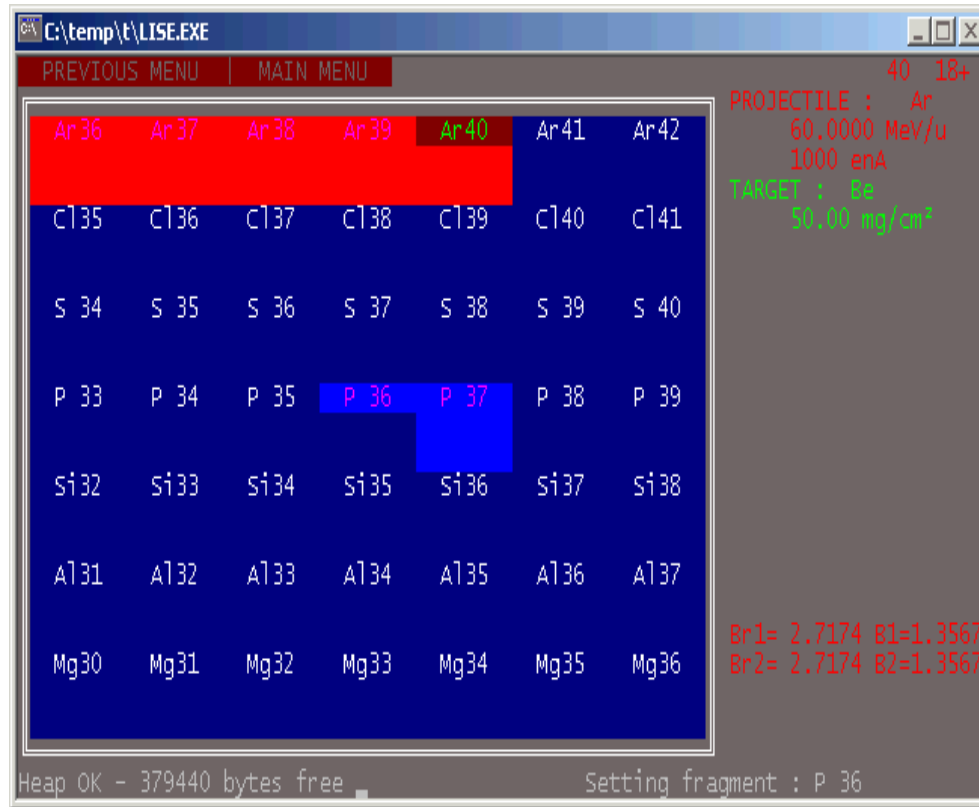
1) D.Bazin and B.Sherrill, Phys.Rev.E50 (1994) 4017.

1990-1993
D.Bazin, MSU
O.Sorlin, Orsay
v.2.1-2.3

The deliberate choice of personal computers (PCs) to implement the program was made for two reasons:

- * to make use of user-friendly features (menus, etc.);
- * so that the program could be used in different laboratories worldwide without modification.

Evolution shows this was a good choice!



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

Almost 593 kBytes

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.

1994-1997
O.T., GANIL
v.2.3 – 2.9

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

1998
O.T., GANIL
v.3.1

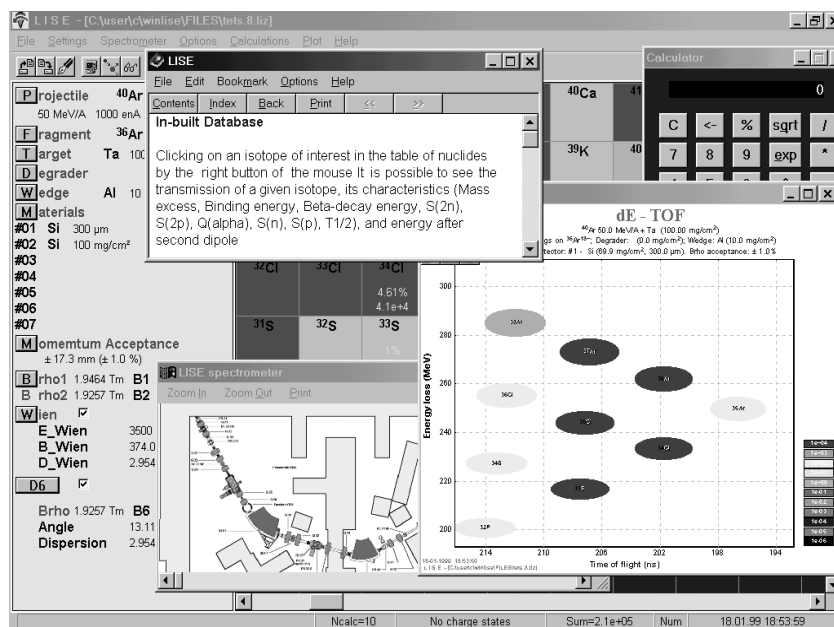
LISE operates under MS Windows

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 0.46632471 Tesla 0.5737953 Tesla
	Brho2	1.14931	Tm	39	
	Radius 1	2.598	m	40	
	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

RECENT DEVELOPMENT

Fragment-Separator experts meeting @ 03 . 2008 . MSU	v. 8.1.24	(28-FEB-2008)
Fragment-Separator experts meeting @ 12 . 2010 . GSI	v. 9.2.33	(10-DEC-2010)
Fragment-Separator experts meeting @ 12 . 2013 . RIKEN	v. 9.7.01	(01-NOV-2013)

3 years development report

Official release	v. 9.9	(05-JAN-2015)
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Fragment-Separator experts meeting @ 08 . 2016 . MSU	v. 9.10.345	(22-AUG-2016)
--	-------------	---------------

v.10 October 2016

v.9.9

- Optics: S & E construction methods
- Extended configurations in LISE⁺⁺
- Compensating dipole
- Multipole : Quadrupole & Sextupole superposition
- TRANSPORT code file import to LISE⁺⁺
- Range Optimizer (Gas cell utility) update

- Extended Configurations

- Regular support routine:
 - user requests, calculation optimization, fix of bugs, interface improvement, Databases and other updates

v.9.10.345

- Update of Fusion reaction mechanism
- Optics minimization (up to 2nd order)
- Reverse configurations: ray trajectory reconstruction
- Radiation Residue Calculator
- ETACHA4 (GUI) (still under construction)

- Others notable
 - Decay Branching Database
 - Ionization energy database & Ion mass calculator
 - Utility "Angular Straggling & Rutherford scattering probabilities in compound"
 - Rutherford scattering of primary beam in target in MC mode
 - FRIB mass tables in the LISE⁺⁺ package
 - Second order optics calculations of electric dipole

V. 9.9
(BRIEFLY)

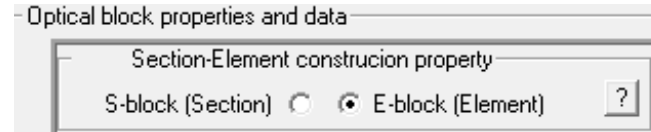
s-block

(section, segment configuration)

Construction property

e-block

(element, extended configuration)



1. Main feature of E-block – possibility to calculate the optical matrix by means of LISE++ : so, this construction property tells to the code how and where this block can be used
2. **This new construction property allows split properties and utilities of optical blocks.**
So, less confusion for the user, more simple and informative
3. **Use new commands only for blocks of specified construction properties**
4. All optical block classes are separated on three construction categories (on 11/14/2014):
 - a. only e-blocks (6 classes);
 - b. only s-blocks (6 classes);
 - c. property defined by user (M & E- dipoles, Wien-filter)

Property	S-block (sector)	E-block (element)
Optical matrix can be calculated inside of the code	no	yes
Length of block	manually	calculated
Drawing quadrupoles in scheme	allowed	no
Aperture property	no	yes
Slits after block property	yes	yes but not recommended
Angular acceptance block property	yes	yes but not recommended
Aperture property	no	yes
Block use in the segmentation process (in future)	no	yes
Block use in the minimization process	no	yes
Export/Import separator configuration (LISE++ ↔ other beam transport codes)	no	yes
User level	Regular	Expert
Efficiency to calculation model, designation	Effective with analytical calculations for experiment planning	Very useful with Monte Carlo calculations including fragment separator design

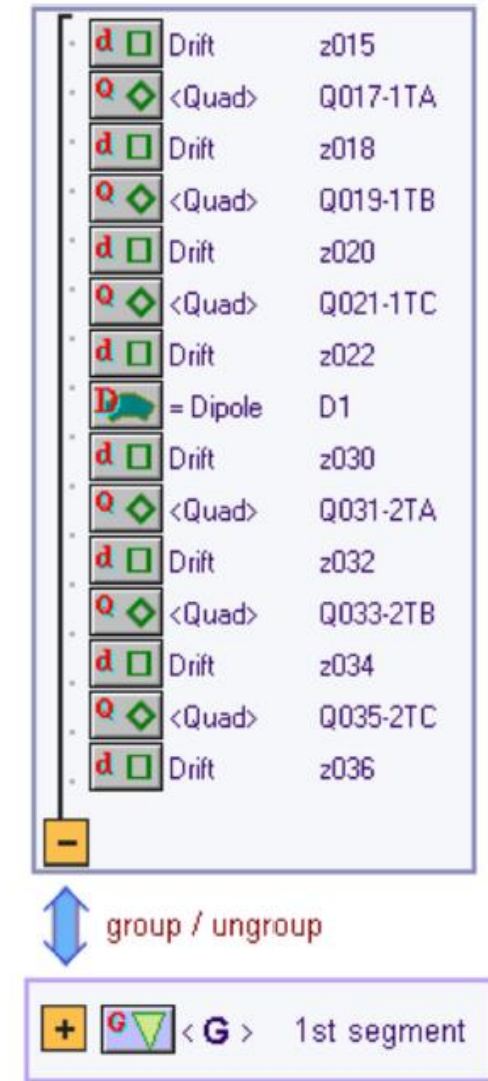







Fig. 2. The new LISE++ feature for converting a series of extended blocks to a single segmented block.

 ➤ **Classical or original (segmented) configuration:**
dispersive block contains quads, drifts, dipole and other optical components

 ➤ **Extended (elemental) configuration:**
like in the TRANSPORT or COSY codes all elements are separated, and their matrices can be calculated by the LISE⁺⁺ code

Some definitions will be used in the presentation

-  User
-  Advanced
-  Beam physicist

So, let's take the first dispersive block of A1900 as an example

segmented Only 1 block after stripper

Taken from TRANSPORT

Block matrix

1. X	-2.28459	0.009	0	0	0	29.2533
2. T	1.06245	-0.44189	0	0	0	-0.00283
3. Y	0	0	0.73853	0.0022	0	0
4. F	0	0	3.74271	1.36526	0	0
5. L	3.10738	-1.2927	0	0	1	5.7769
6. D	0	0	0	0	0	1

extended 16 blocks after stripper

Calculated by LISE⁺⁺ including 2nd order (see next page)

Global matrix

-2.30361	0.00906	0	0	0	28.88518	[mm]
1.07573	-0.43836	0	0	0	-0.00018	[mrad]
0	0	0.73839	0.00259	0	0	[mm]
0	0	3.731	1.36722	0	0	[mrad]
3.10724	-1.26623	0	0	1	-2.42226	[mm]
0	0	0	0	0	1	[%]
/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

Classical Segmented & Extended configurations



Classical (segmented) configuration:

- Fast transmission calculations
- Optical matrices can be input by user or linked to COSY maps
- Simple and compact description of optical system
- Effective with analytical calculations for experiment planning



Extended (elemental) configuration:

- Allows detailed analysis of transmission
- Optical matrices can be input by user, linked to COSY maps or calculated in the LISE++ code, and used in segmented configurations
- Tools to obtain angular acceptances, (which can be entered into classical segmented configurations)
- Tools for displaying ion-beam optics



Very useful with Monte Carlo calculations including fragment separator design

Types of transmission calculations



“Distribution” (analytical) method



- Fast calculations
- All internal optimization procedures in the code are based on this method
- Mostly used with segmented configurations for experiment planning
- Calculation of very small transmission values (for example charge states of primary beams)

LISE ver.1	“Distribution”	: 1986
LISE ver.4	“Distribution2”	: 2000
LISE++ ver.6	“Distribution4”	: 2002



Monte Carlo method: (since 2007)



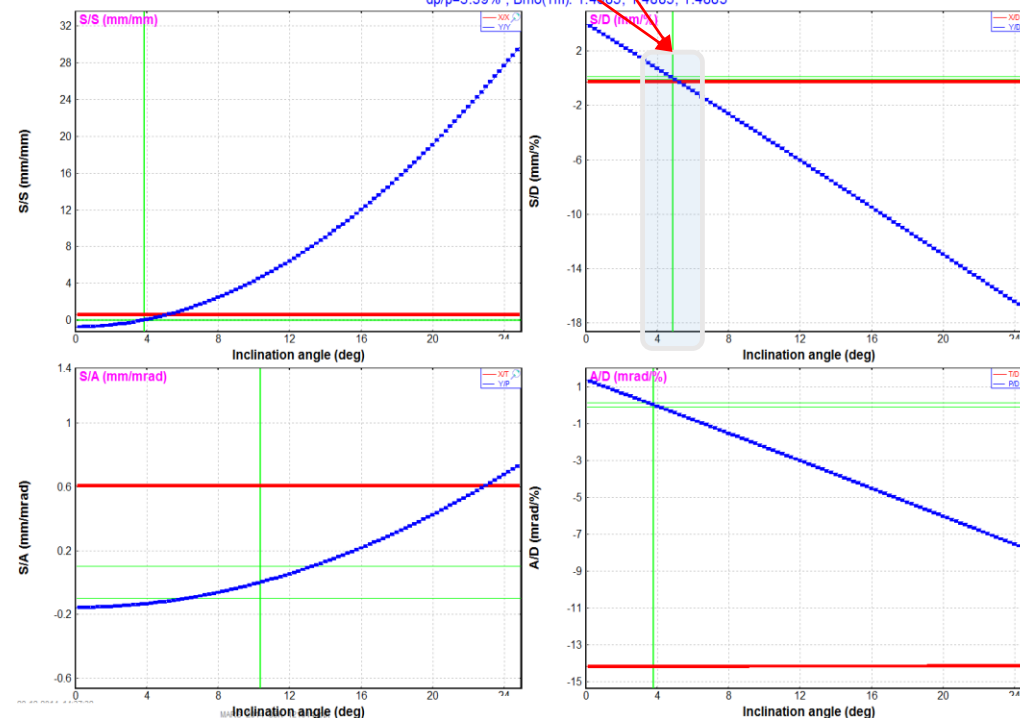
- Used to benchmark the fast “Distribution” method
- Allows detailed analysis of transmission with extended configurations
- Allows using High Order Optics (up to fifth order)
- Allows observation of correlations between parameters in different blocks
- Includes gating on all correlations in parameters (four gates)
- Tools for displaying ion-beam optics
- Useful for fragment separator design
- Some optical blocks (Solenoid, RF buncher) are calculated exactly only in MC mode

- The Compensating dipole can own only “E-block” property.
- **The matrices (up to second order) are calculated by the code** based on its geometry (L1,L2,Platform inclination angle, Y-gap)
- **Calculation of platform inclination angle** based on user’s condition request

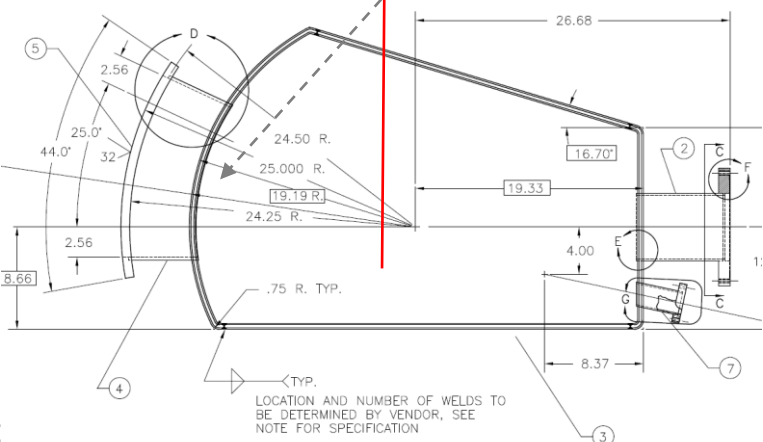
calculation of platform inclination angle

Compensating Dipole: Platform Inclination Angle

Compensating Dipole : 'D3' Block to match GOM values : "drift"
³⁶Ar (36.0 MeV/u) + H2 (100 mm); Settings on "K"; Config: MDSSSSDSSSSSSSDSONSSCSOS...
 dp/p=3.39%; Brho(Tm): 1.4885, 1.4885, 1.4885



calculation of platform inclination angle



- There is not Quadrupole & Sextupole superposition in the TRANSPORT code.
- Or only Quadrupole element (command 5.), or only Sextupole (command 18.)
- Now LISE⁺⁺ allows Quadrupole & Sextupole superposition

Magnetic Multipole Settings

	QUADrupole	SEXTupole	
L_eff (effective length)	1		m
B (field at pole tip)	10	1.	kG
Radius (half-aperture)	10	10	cm
Multipole fixed Brho-value corresponding to the setting fragment	1		Tm
	<input type="button" value="Fix current value"/>		
<input checked="" type="checkbox"/> calculate 2nd order matrix elements			

LISE⁺⁺

```

Block: "Multi_LISE" Matrices: "LOCAL"
transport format [cm-mrad]

* TRANSFORM 1 *
1 [X]: -9.9979e-01 -6.5000e-04 0 0 0 0
2 [T]: +6.5407e-01 -9.9979e-01 0 0 0 0
3 [Y]: 0 0 +1.1833e+01 +3.7286e-01 0 0
4 [F]: 0 0 +3.7290e+02 +1.1833e+01 0 0
5 [L]: 0 0 0 0 +1.0000e+00 0
6 [D]: 0 0 0 0 0 +1.0000e+00

-----

* TRANSFORM 2 *
1 1: -6.6674e-03
1 2: +8.7200e-06 -1.3330e-05
1 3: 0 0 +2.9005e-01
1 4: 0 0 +1.7652e-02 +2.7006e-04
1 5: 0 0 0 0 0
1 6: -3.2704e-04 +4.9662e-04 0 0 0 0

-----

2 1: -2.1793e-03
2 2: +1.3326e-02 +8.7200e-06
2 3: 0 0 +1.7645e+01
2 4: 0 0 +1.1202e+00 +1.7652e-02
2 5: 0 0 0 0 0
2 6: -5.0316e-01 -3.2704e-04 0 0 0 0

-----

3 1: 0
3 2: 0
3 3: +9.2706e-02 +7.4876e-03 0
3 4: -6.2238e-05 +1.9029e-04 0 0
3 5: 0 0 0 0
3 6: 0 0 -1.8643e-01 -4.0523e-03 0 0

-----

4 1: 0
4 2: 0
4 3: -9.2559e-02 +2.8299e-01 0
4 4: -3.2753e-02 +7.4254e-03 0 0
4 5: 0 0 0 0
4 6: 0 0 -7.7810e+00 -1.8643e-01 0 0

-----

5 1: 0
5 2: 0
5 3: 0
5 4: 0
5 5: 0
5 6: 0

-----

6 1: 0
  
```

COSY

```

Block: "Multi_COSY" Matrices: "LOCAL"
transport format [cm-mrad]

* TRANSFORM 1 *
1 [X]: -9.9979e-01 -6.5000e-04 0 0 0 0
2 [T]: +6.5407e-01 -9.9979e-01 0 0 0 0
3 [Y]: 0 0 +1.1833e+01 +3.7286e-01 0 0
4 [F]: 0 0 +3.7290e+02 +1.1833e+01 0 0
5 [L]: 0 0 0 0 +1.0000e+00 0
6 [D]: 0 0 0 0 0 +1.0000e+00

-----

* TRANSFORM 2 *
1 1: -6.6674e-03
1 2: +8.7200e-06 -1.3330e-05
1 3: 0 0 +2.9005e-01
1 4: 0 0 +1.7652e-02 +2.7006e-04
1 5: 0 0 0 0 0
1 6: -3.2704e-04 +4.9662e-04 0 0 0 0

-----

2 1: -2.1793e-03
2 2: +1.3326e-02 +8.7200e-06
2 3: 0 0 +1.7645e+01
2 4: 0 0 +1.1202e+00 +1.7652e-02
2 5: 0 0 0 0 0
2 6: -5.0316e-01 -3.2704e-04 0 0 0 0

-----

3 1: 0
3 2: 0
3 3: +9.2706e-02 +7.4876e-03 0
3 4: -6.2238e-05 +1.9029e-04 0 0
3 5: 0 0 0 0
3 6: 0 0 -1.8643e-01 -4.0523e-03 0 0

-----

4 1: 0
4 2: 0
4 3: -9.2559e-02 +2.8299e-01 0
4 4: -9.7583e-02 +7.4254e-03 0 0
4 5: 0 0 0 0
4 6: 0 0 -7.7810e+00 -1.8643e-01 0 0

-----

5 1: -2.4837e-02
5 2: +2.1390e-07 -2.5163e-05
5 3: 0 0 -1.0781e+00
5 4: 0 0 -6.9514e-02 -1.1281e-03
5 5: 0 0 0 0
5 6: 0 0 0 0 0 0

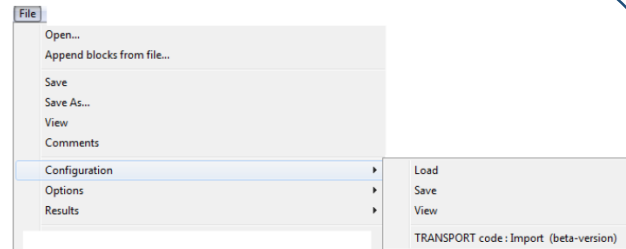
-----

6 2: 0
6 3: 0 0 0
  
```

COSY, Q (10) +S (1), R=10cm Br=1 Tm

How to create LISE++ setup from a TRANSPORT “deck”

Version 9.8.89, Menu “File → Configurations → Transport code : import”



Rules for interpreting the deck

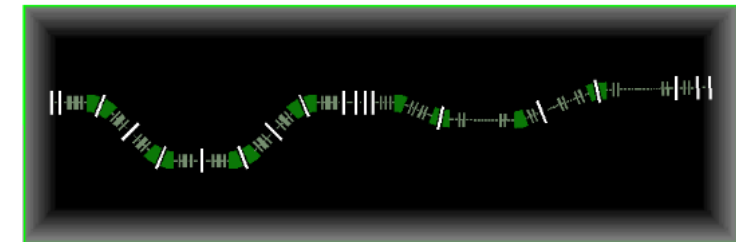
1. The first line always contains a title
2. Spaces are ignored at the beginning of line
3. LISE++ is looking for a line beginning with “0” to start interpretation
4. If “0” line is absent, then LISE++ terminates interpretation
5. Next line after “0”-line begins the “deck”, LISE++ creates an empty configuration and starts to analyze the Transport file
6. A deck line is valid if it starts with a number (“-”, text and so on lines are not analyze)
7. Labels (block names) are selected by characters [“], [’] or [/]
8. LISE++ uses semicolons to separate inputs on one line
9. LISE++ ends importation when a line starts with “SENT”

LISE++ settings for initial empty configuration

1. Target, stripper thicknesses are zero
2. Setting fragment is the same as the beam
3. Mechanism set to Projectile fragmentation
4. First block after stripper will be 0-length “tuning” dipole
5. After TRANSPORT file is imported, LISE++ runs automatically the “save as” file dialog

Transport cards can be imported as of 07/07/2014

1. Beam	2. Pole face rotation
3. Drift	4. Dipole
5. Quadrupole	16.1 Quadratic term of bending field
16.4 X Half-aperture	16.5 Y Half-aperture
16.7 Fringe coefficient K1	16.8 Fringe coefficient K2
16.12 Curvature of entrance face	16.13 Curvature of exit face
18. Sextupole	20. Beam rotation



10. Fitting constraints @ v. 9.10

V. 9.10.345

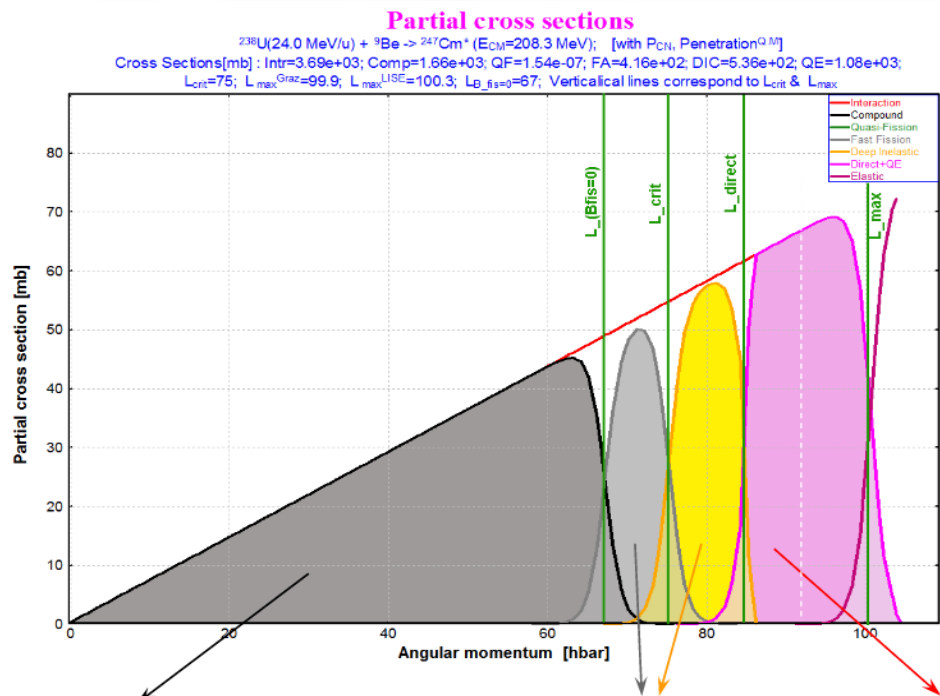
http://lise.nsl.msui.edu/9_10/9_10_Fusion.pdf

A recent update of low-energy reaction mechanism was performed to simulate the dependence of different reaction channels from angular momentum and qualitatively estimate production cross sections in the case of Fusion-Fission and Fusion-Residue.

The development was connected to the analysis of the e547 GANIL experiment

$$\sigma_{ER}^{xn}(E) = \frac{\pi}{k^2} \sum_{l=0}^{\infty} (2l + 1) P_{cont}(E, l) P_{CN}(E^*, l) P_{xn}(E^*, l)$$

Fission channels for ^{238}U (20 MeV/u) + Be,C reactions



Compound fission ~100%
 Fissile Z = 96
 High Excitation Energy

Sequential fission after DIC
 Fissile Z < 92
 High Excitation Energy

Partially go to fission
 Fissile Z~92
 Low Excitation Energy

Fusion or Quasi-Elastic?

Compound or Quasi-Fission?

Fusion or Fast Fission?

Fusion-Evaporation or Fusion-Fission?

Fusion or Deep-Inelastic?

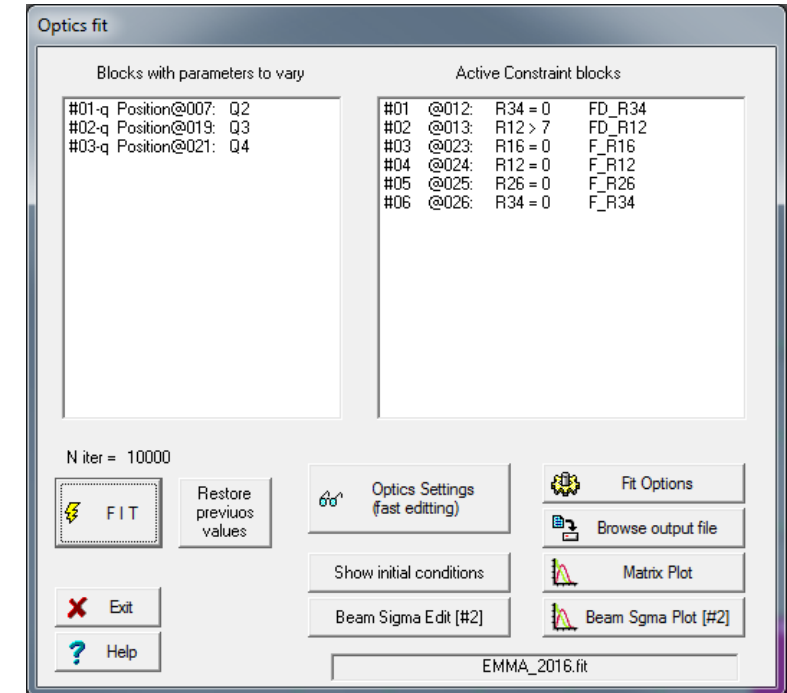
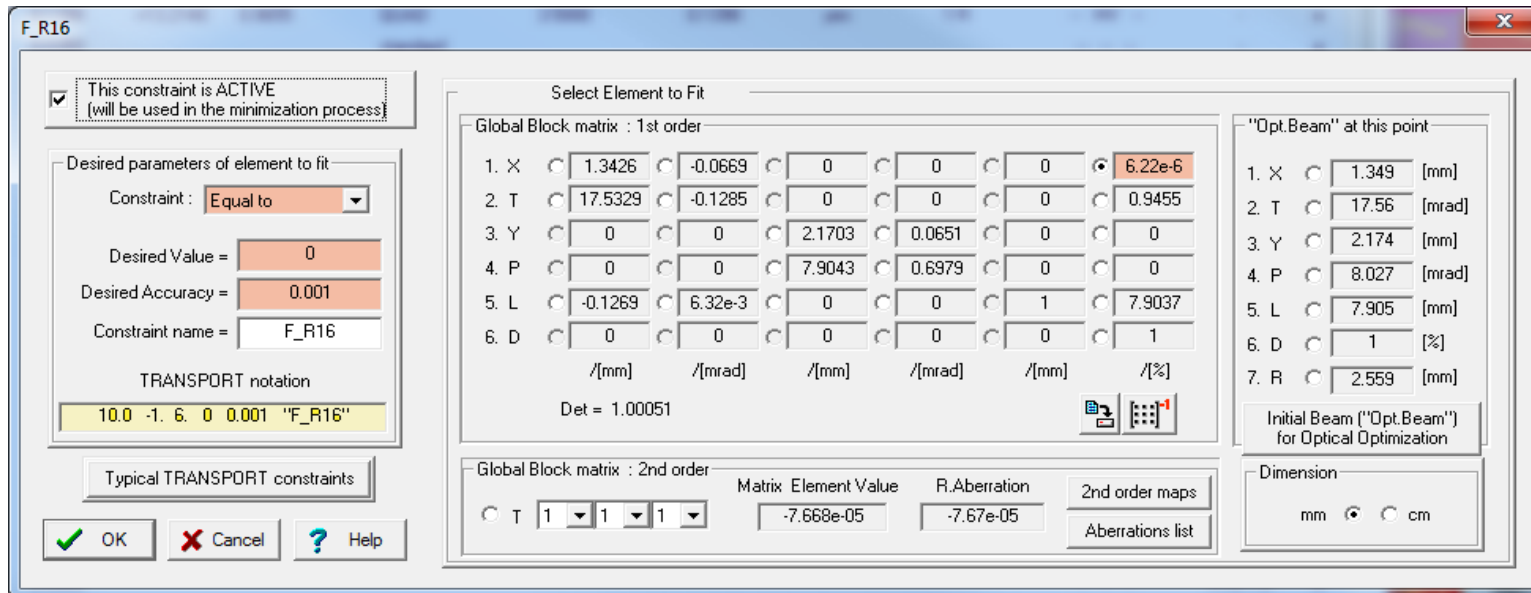
The optics minimization procedure was introduced, based on the “levmar” package by M.I.A. Lourakis using the Levenberg-Marquardt nonlinear least square algorithm [1]. At this stage only the quadrupole fields can be varied to minimize user constraints for matrix (1st and 2nd orders) and beam ellipse elements.

The continuous function has been created to be applied for boundary constraints .

Existed separators. Block size (length, radius) minimization : it is possible, but not necessary

In the future this minimization procedure will be used to define curved profile shape, fragment spatial distributions in Monte Carlo mode, and optimize intensity/purity combination.

[1] levmar: Levenberg-Marquardt nonlinear least squares algorithms in C/C++. M.I.A. Lourakis July 2004. <http://users.ics.forth.gr/~lourakis/levmar>



The “Optics Fit” dialog. The left panel shows optical blocks with varying parameters, whereas blocks with fitting constraints.

This is HUGE-HUGE-HUGE new feature!!!!

The “Fit constraint” dialog. For a constraint the user selects an element from an optical matrix or beam sigma vector, and set its desired value and precision (weight).

The LISE++ reverse technique approach is assumed to be applied for extended (elemental) configurations, that makes it more useful for beam dynamics and benchmarking.

Therefore, local maps are used in reverse configurations, which can be calculated by LISE++, or be entered by the user directly or linked to COSY maps (up to fifth order).

The development was connected to the analysis of the e12006 NSCL experiment.

http://lise.nscl.msu.edu/9_10/ReverseConfiguration.pdf

Application:

- **Momentum vector after reaction in target**

(for example standard S800 technique)

- Reaction mechanism study
- Beam spot
- Angular acceptance vs emittance

- **Beam emittance measurement (X,A,Y,B,E)**

- Study of correlations between beam emittance components

- **Determination of location of background production**

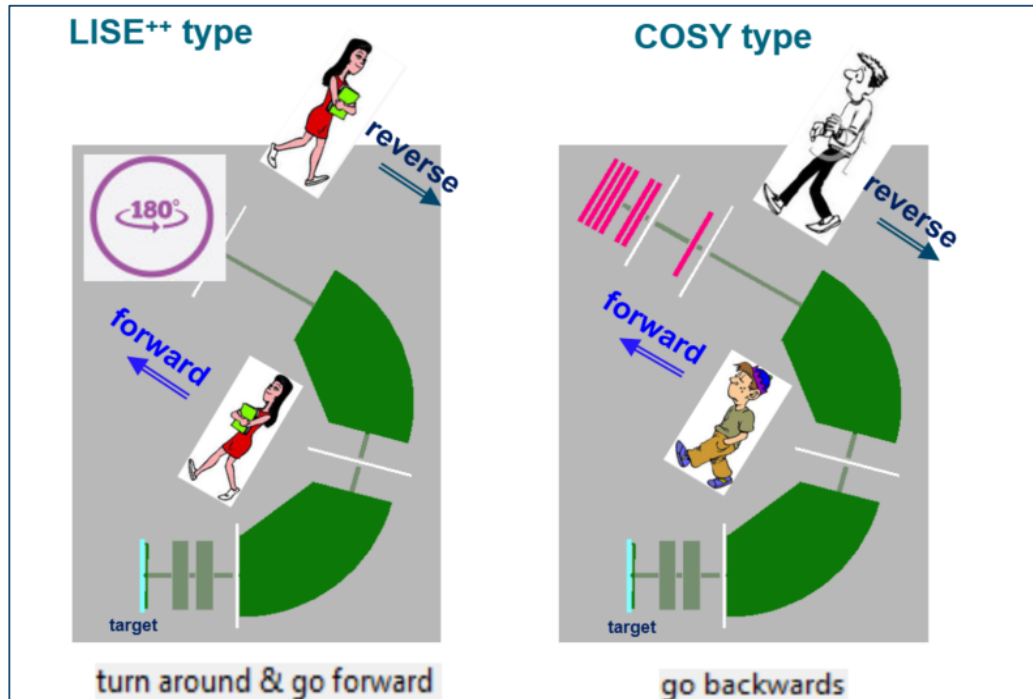
- BigRIPS case : production in the beam-dump
- FRS case (H.W.)

- **Benchmarks based on LISE++ MC apparatus and spectrograph segmentation**

- Beam dynamics visualization
- Beam optics calculation verification
- Experimental analysis and calibrations test

- **Experiment set-up feedback with LISE++ (in future)**

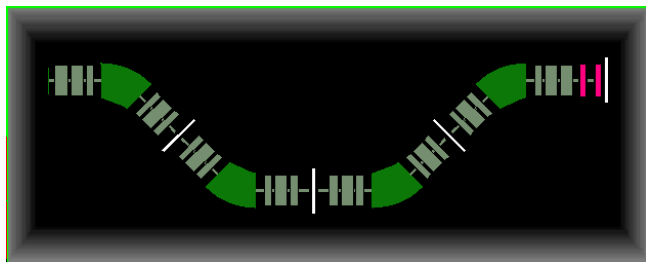
- Obtaining experimental information by detecting devices in some (or one) locations
- Retracing up-stream (or down-stream) from detection locations based
- Analysis, minimization



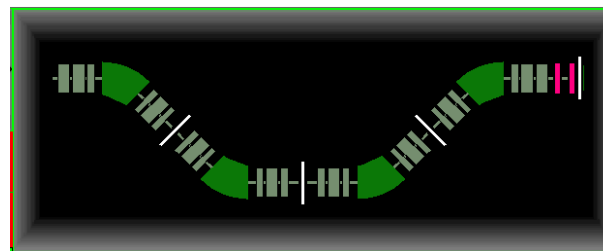
- The coordinate system is changed ($x_n = -x, y'_n = -y_n, L_n = -L$)
- Matrices are calculated by LISE++

- The coordinate system is not changed
- COSY matrices are imported (linked)
- These maps are inverted from the "direct" maps by the COSY procedure "MI"
- Ideal case : invert matrices inside LISE

beam →



← beam



P rojectile	124 Sn ⁵⁰⁺
80 MeV/u	pnA
F ragment	124 Sn ⁵⁰⁺ =beam=
T arget	
Str ipper	
D tuning	Brho 3.2582 Tm
d z015	standard 3.2582 Tm
Q Q017-1TA	QUAD 11.4038 kG
d z018	standard 3.2582 Tm
Q Q019-1TB	QUAD -10.5976 kG
d z020	standard 3.2582 Tm
Q Q021-1TC	QUAD 7.6243 kG
d z022	standard 3.2582 Tm
D D1	Brho 3.2582 Tm

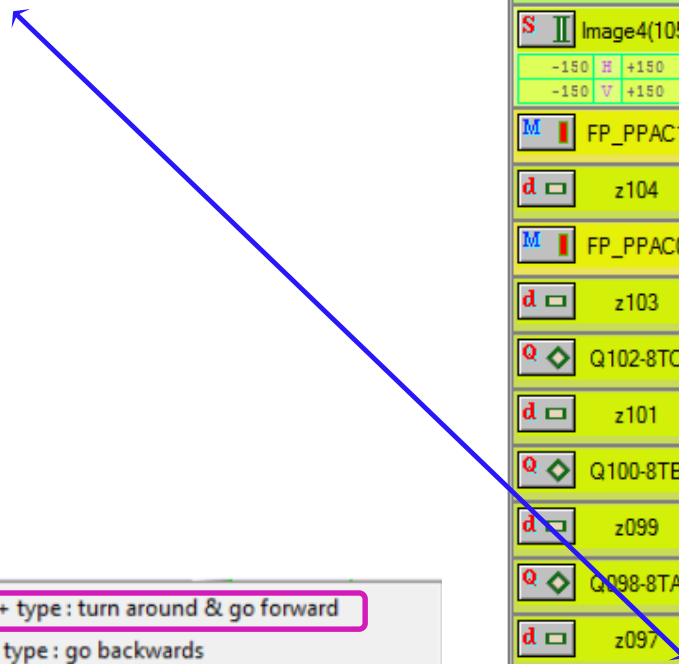
P rojectile	124 Sn ⁵⁰⁺
79.5 MeV/u	pnA
F ragment	124 Sn ⁵⁰⁺ =beam=
T arget	
Str ipper	
D tuning	Brho 3.2477 Tm
S Image4(105)	slits
	-150 X +150 -150 Y +150
M FP_PPAC1	AI -2 mrg/cnr2
d z104	standard 43.2 cm
M FP_PPAC0	AI -2 mrg/cnr2
d z103	standard 37.5 cm
Q Q102-8TC	QUAD 6.0177 kG
d z101	standard 17.56 cm
Q Q100-8TB	QUAD -10.195 kG
d z099	standard 17.2 cm
Q Q098-8TA	QUAD 8.3052 kG
d z097	standard 52.6 cm
D D4	Brho 3.2582 Tm

Load
Save
View

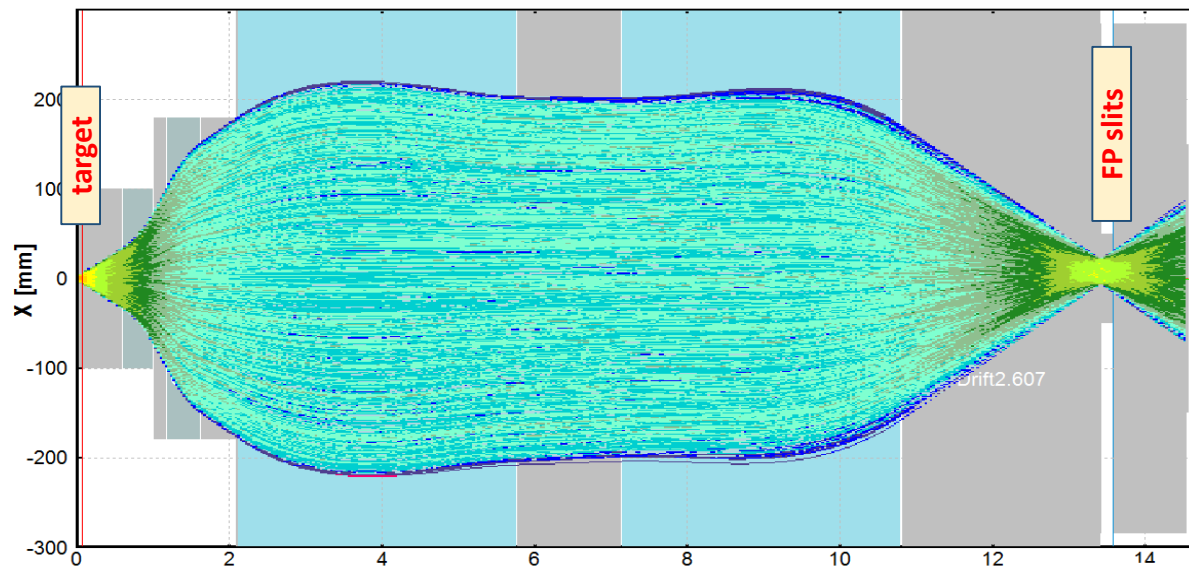
TRANSPORT code : Import (beta-version)

Create reverse configuration (beta-version) ▶

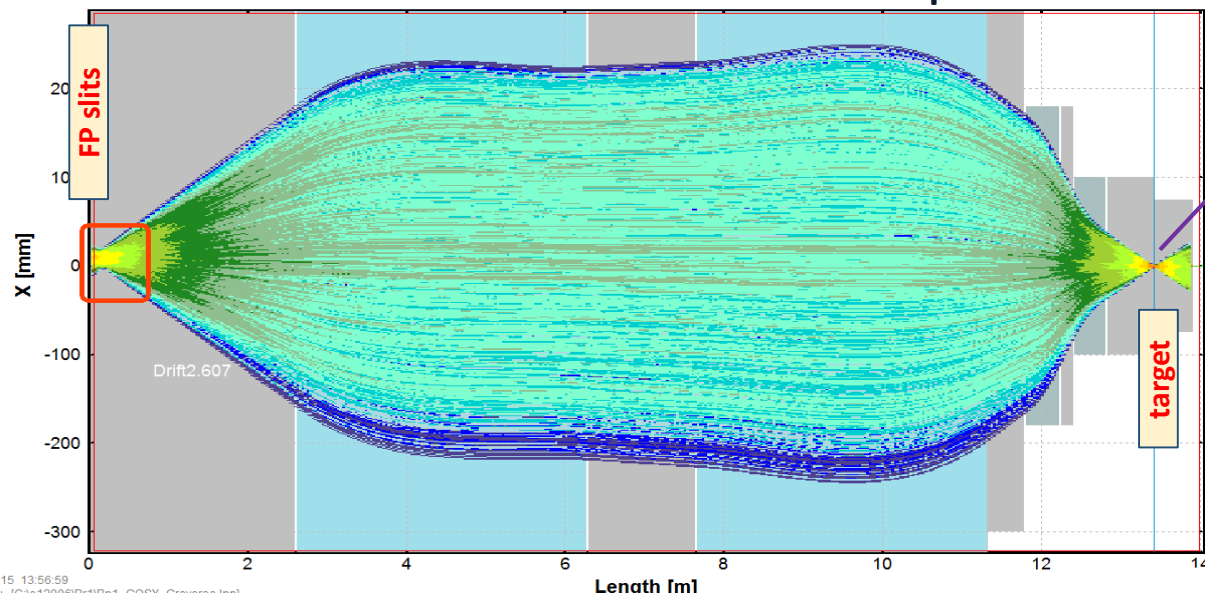
LISE++ type : turn around & go forward
COSY type : go backwards



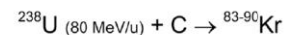
S800 Forward direction : LISE++ simulation



S800 Backward direction : e12006 experiment



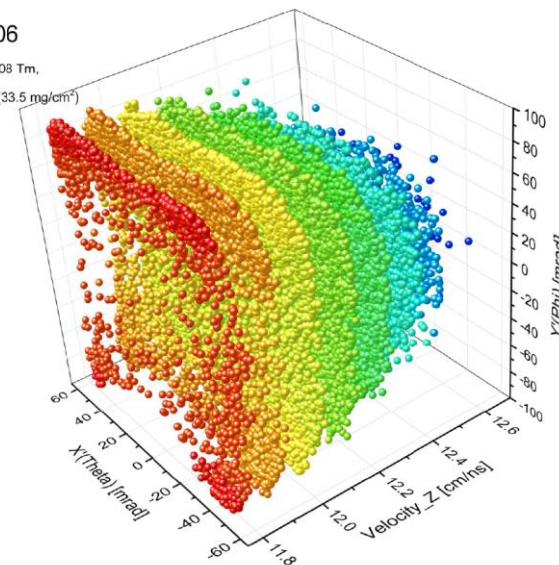
Experimental (e12006) velocity vector distributions of Krypton isotopes after target



e12006

$B_p=3.34308 \text{ Tm}$,

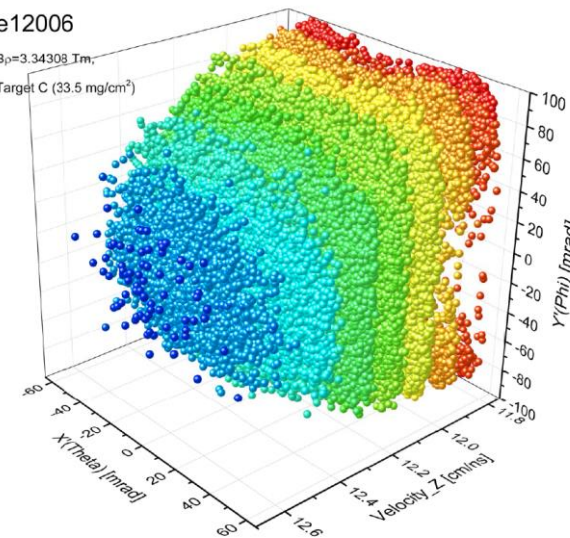
Target C (33.5 mg/cm²)



e12006

$B_p=3.34308 \text{ Tm}$,

Target C (33.5 mg/cm²)



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

"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)

DANGER HIGH RADIATION AREA AUTHORIZED PERSONNEL ONLY

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

Calculate Options

1D : Residues as function of time
 1D : Activity as function of time
 2D : Final Residues (@ TF)

Elapsed time is 00:00:06.11 or 6.11 sec

CAUTION RADIATION AREA

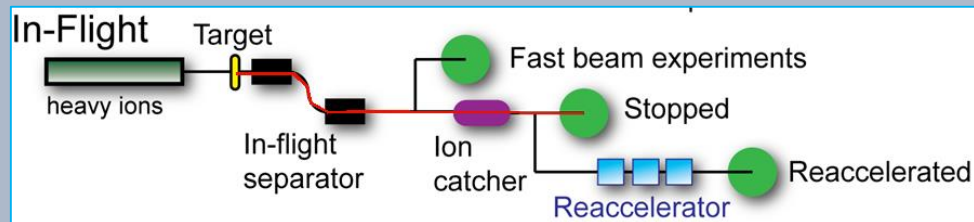
zoom

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

Table 1. Priority isotopes for harvesting at FRIB. These isotopes were identified at a Working Group meeting in Santa Fe, NM September 30 – October 1, 2010.

Isotope	Half-life	Application
^{32}Si	160 y	Tracer; geology and botany
^{44}Ti	60 y	Medicine, astrophysics, nuclear structure
^{48}V	16 d	Stockpile Stewardship
^{67}Cu	2.6 d	Medicine
^{85}Kr	10.0 d	Astrophysics, stockpile stewardship
Eu*		Stockpile Stewardship
^{211}Rn	14.6 h	Medicine
^{225}Ra	14.9d	Medicine, Electric Dipole Moment
^{225}Ac	10.0 d	Medicine



settings

The screenshot shows the FRIB control interface with the following settings:

- Projectile:** $^{58}\text{Ni}^{28+}$, 140 MeV/u, 1 pA
- Fragment:** $^{44}\text{Ti}^{22+}$
- Target:** ^9Be , 584.291 $\mu\text{g/cm}^2$
- Stripper:**
- D1:** Brho, 2.9668 Tm
- I1_slits:** slits, -100 H, +100
- D2:** Brho, 2.9668 Tm
- I2_slits:** -150 H, +150
- I2_wedge:** AI, 100 $\mu\text{g/cm}^2$
- D3:** Brho, 2.8676 Tm
- D4:** Brho, 2.8676 Tm
- FP_PPAC0:** AI, 2 $\mu\text{g/cm}^2$
- FP_PPAC1:** AI, 2 $\mu\text{g/cm}^2$
- FP_slits:** slits, -8 H, +8, -25 V, +25
- FP_PIN:** Si, 513 $\mu\text{g/cm}^2$
- FP_SCI:** C9H10, 100 mm

A blue callout box points to the 'I2_slits' setting with the text: "Use the wedge for purity".

⁴⁴Ti case : Residues

Radiation residue calculator

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

Mode to implant:

- 1. One nucleus to implant. Chose manually here
- 2. List of isotopes to implant from file
- 3. Select detector to obtain the list of isotopes stopped in **FP_SCI** Refresh N of isotopes = 36

Total Irradiation Rate: Rate = 2.271e+06 pps

Irradiation (Implantation): IT: Irradiation Time [sec] = 36000, N of DI @ time (IT) = 53

Radiation Residues as Function of time (DT): DT: Decay Time after irradiation (sec) = 36000, N of DI @ time (FT) = 38, Total Yield @ time (FT) = 8.18e+10

Buttons: Calculate, Options, View Results (Text), Quit, Link

Elapsed time is 00:00:09.52 or 9.52 sec

Isotopes selected by the Fragment-Separator are implanted in FP_SCI detector

http://lise.nsl.msu.edu/9_10/radiation/44Ti%20from%2058Ni.lpp

10 hours of irradiation, 10 hours of decay :
⁴⁴Ti's number of atoms is highest!

Radiation Residue calculations results

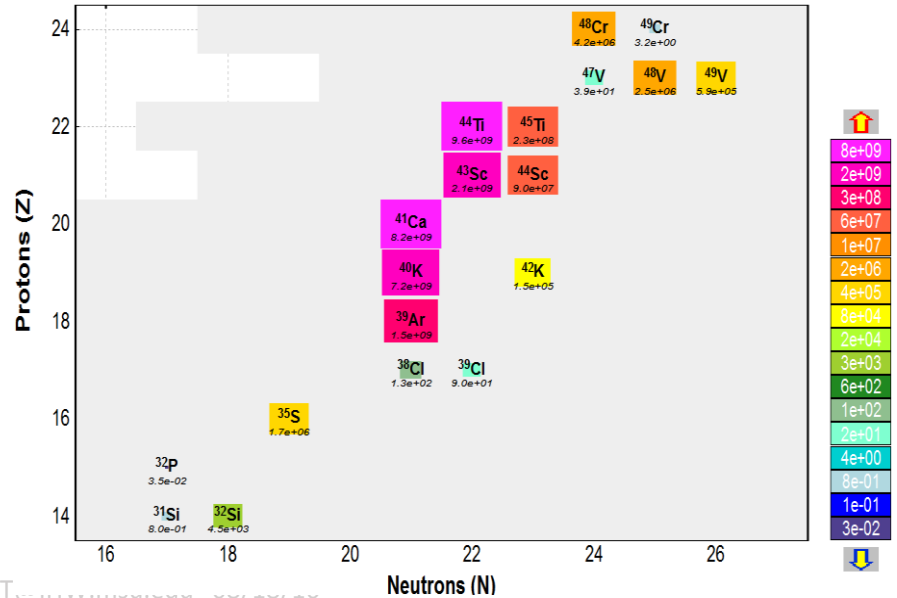
Radiation residue calculator
! Implantation detector : "FP_SCI" (36 different isotop
! Irradiation Time (IT) = 3.60e+04 sec; Decay Time (DT)
! N_Implant=1000, N_Resid=1000, Abs.Error=1.0e-11, Rel.Er

A_EI	Z	N	Residue Atoms	T1/2, sec
31Si	14	17	7.974e-01	9.438e+03
32Si	14	18	4.529e+03	4.826e+09
32P	15	17	3.458e-02	1.232e+06
35S	16	19	1.727e+06	7.549e+06
38Cl	17	21	1.338e+02	2.234e+03
39Cl	17	22	8.975e+01	3.372e+03
39Ar	18	21	1.459e+09	8.484e+09
40K	19	21	7.219e+09	3.936e+16
42K	19	23	1.547e+05	4.450e+04
41Ca	20	21	8.206e+09	3.135e+12
43Sc	21	22	2.118e+09	1.401e+04
44Sc	21	23	9.034e+07	1.429e+04
44Ti	22	22	9.559e+09	1.864e+09
45Ti	22	23	2.347e+08	1.109e+04
47V	23	24	3.880e+01	1.956e+03
48V	23	25	2.545e+06	1.380e+06
49V	23	26	5.866e+05	2.851e+07
48Cr	24	24	4.217e+06	7.762e+04
49Cr	24	25	3.209e+00	2.538e+03

Radioactive decay residues

Implantation detector : "FP_SCI" (36 different isotopes)

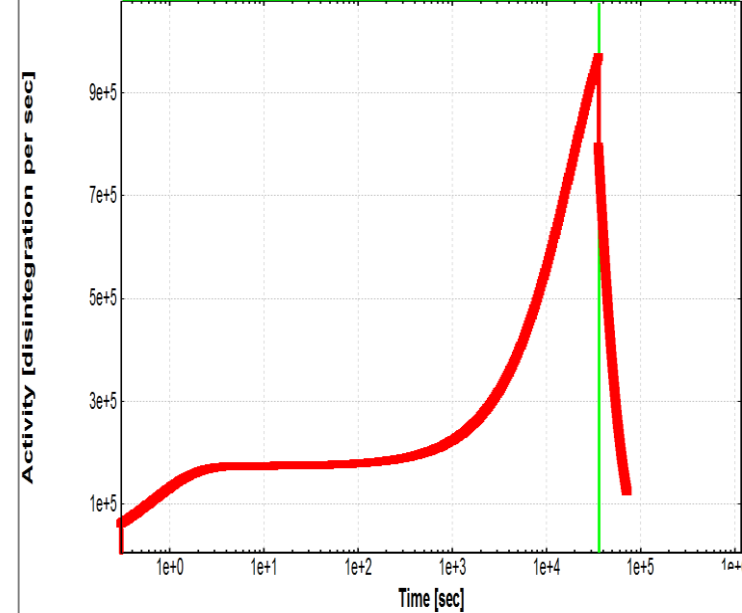
Irradiation Time (IT) = 3.60e+04 sec; Decay Time (DT) = 3.60e+04 sec; Plot only Radioactive
N_Implant=1000, N_Resid=1000, Abs.Error=1.0e-09, Rel.Error=1.0e-03, Threshold=1.0e-08, Model="O"



Activity

Implantation detector : "FP_SCI" (36 different isotopes)

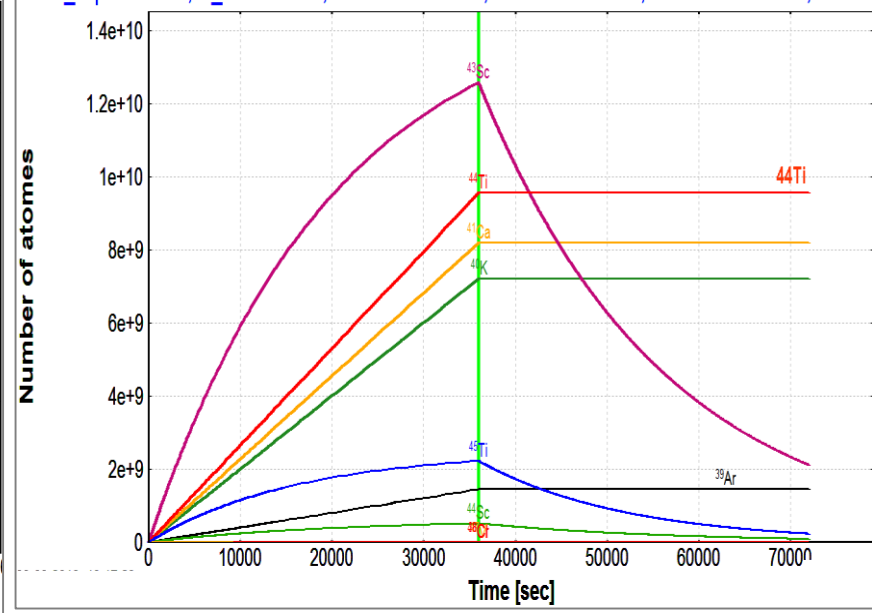
Irradiation Time (IT) = 3.60e+04 sec; Decay Time (DT) = 3.60e+04 sec; Plot only Radioactive
N_Implant=1000, N_Resid=1000, Abs.Error=1.0e-09, Rel.Error=1.0e-03, Threshold=1.0e-08, Model="O"



Evolution of Radiation Residue Yield

Implantation detector : "FP_SCI" (36 different isotopes)

Irradiation Time (IT) = 3.60e+04 sec; Decay Time (DT) = 3.60e+04 sec; Plot only Radioactive
N_Implant=1000, N_Resid=1000, Abs.Error=1.0e-09, Rel.Error=1.0e-03, Threshold=1.0e-08, Model="O"



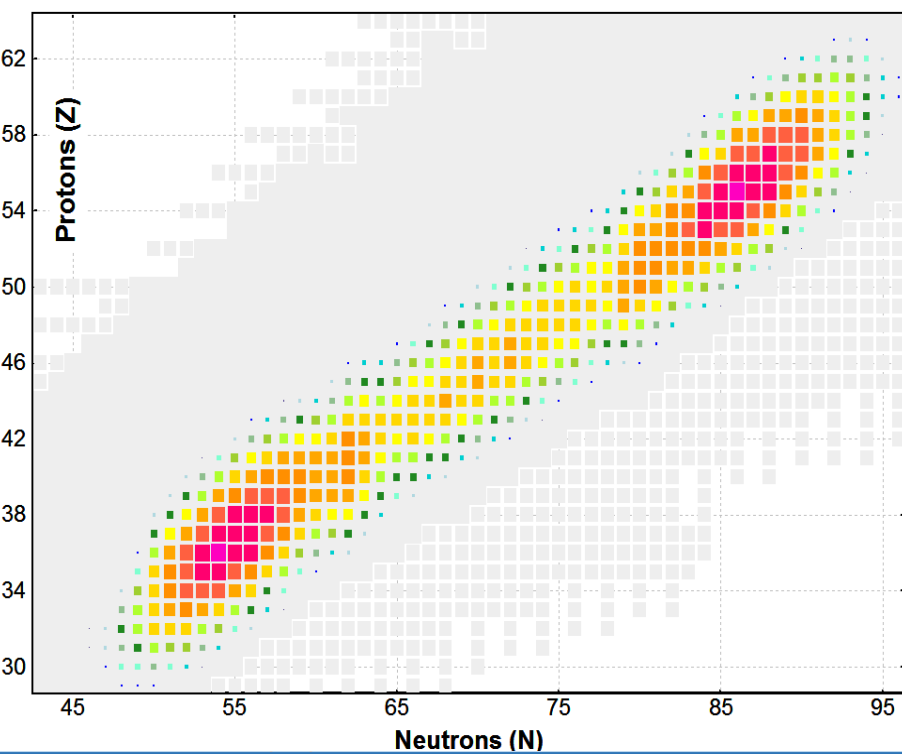
This file has been produced by LISE++ with next settings and Coulomb Fission mechanism

P rojectile	$^{238}\text{U}92+$
1000 MeV/u	1 pA
F ragment	$^{130}\text{Te}52+$
T arget	^{207}Pb
Stripper	1 mm
M aterial 1	Si
Faraday Cup 1	100 mm

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

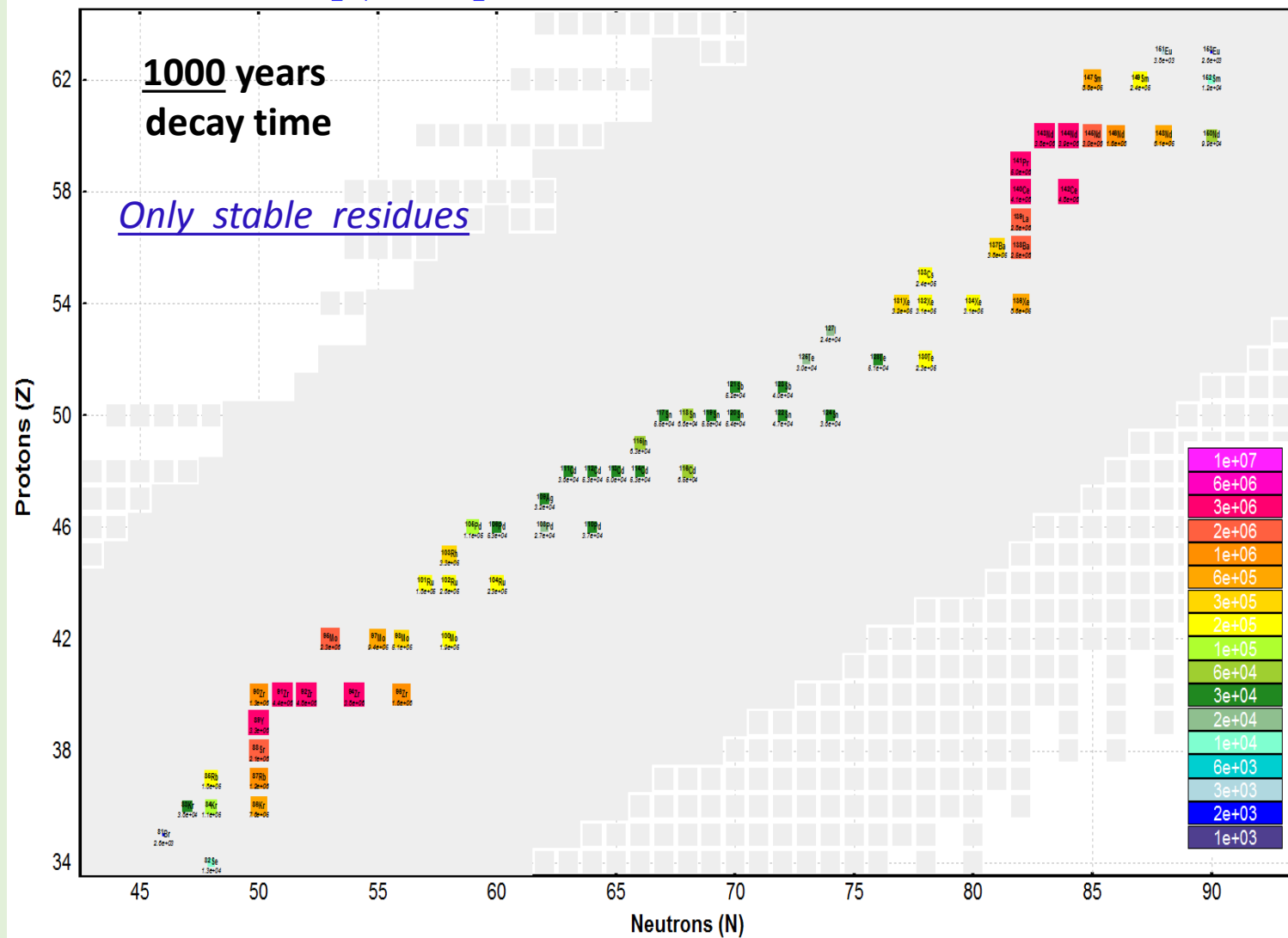
Implanted isotopes file : "G:\238U_CoulombFission.radlist" (490 isotopes)

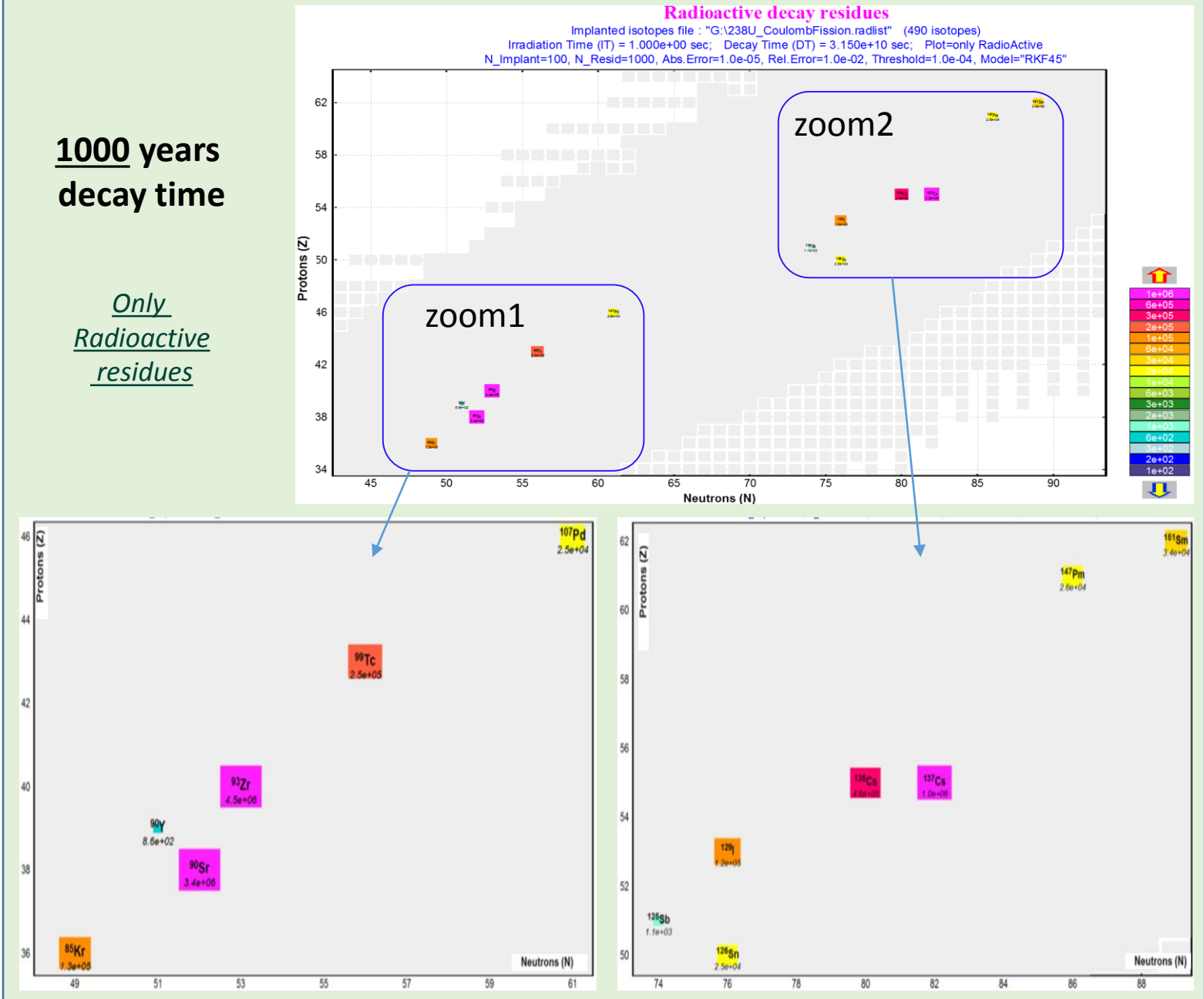
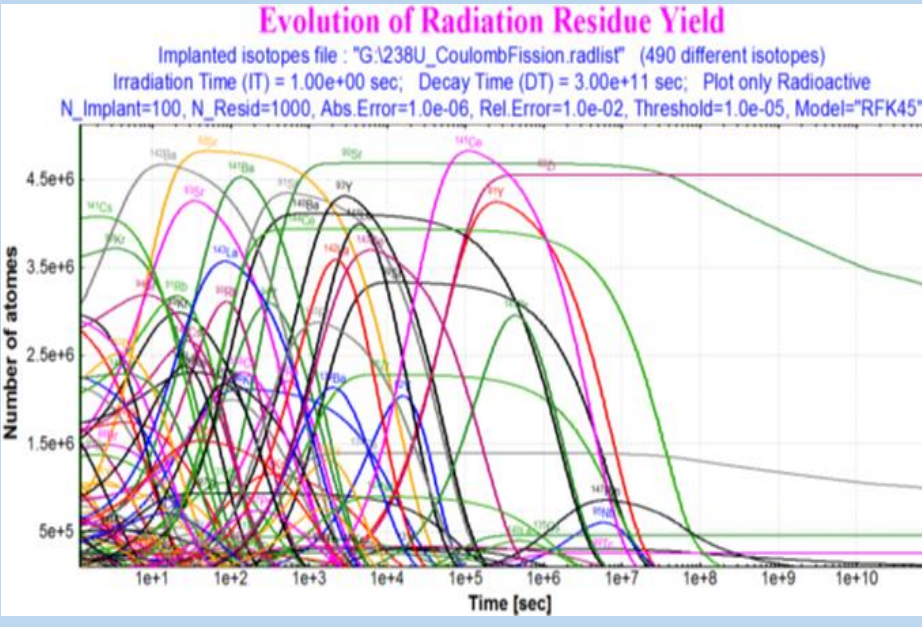
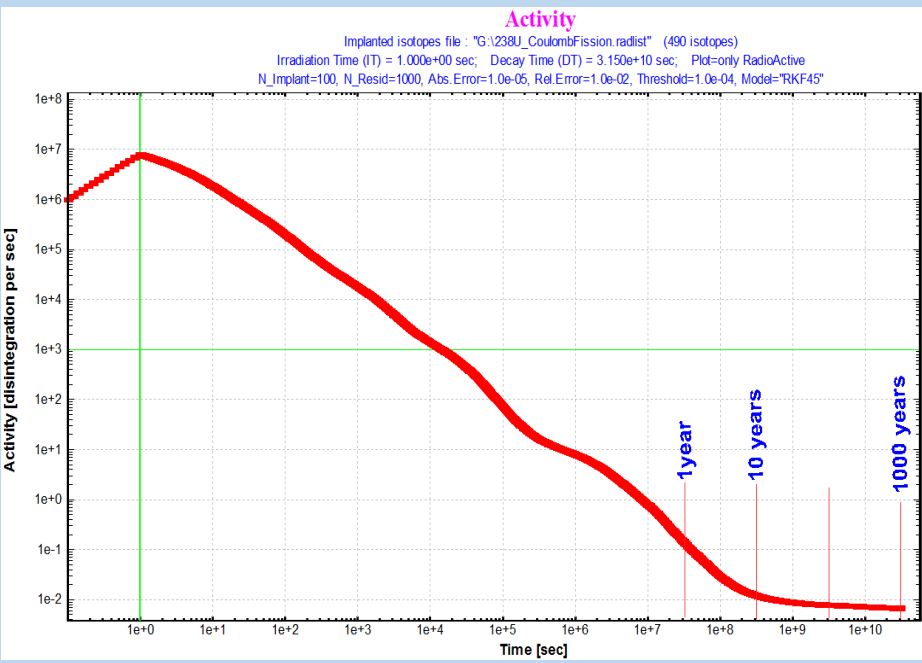
Irradiation Time (IT) = 1.000e+00 sec; Decay Time (DT) = 3.150e+10 sec

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

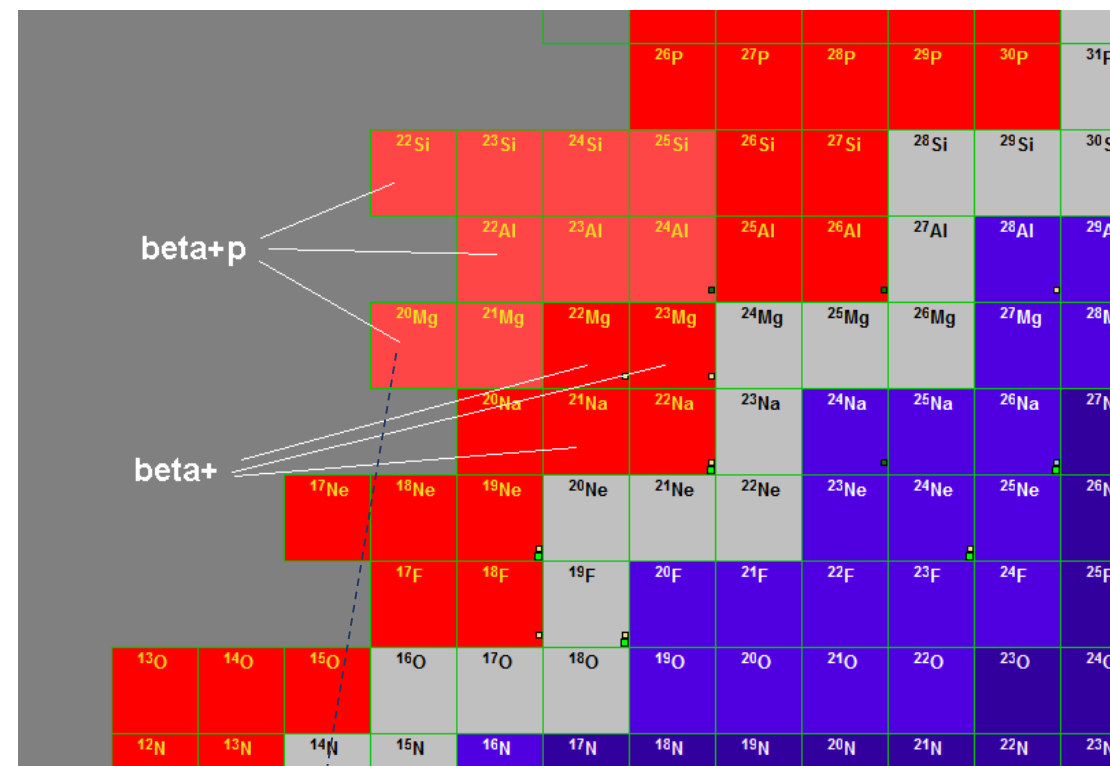
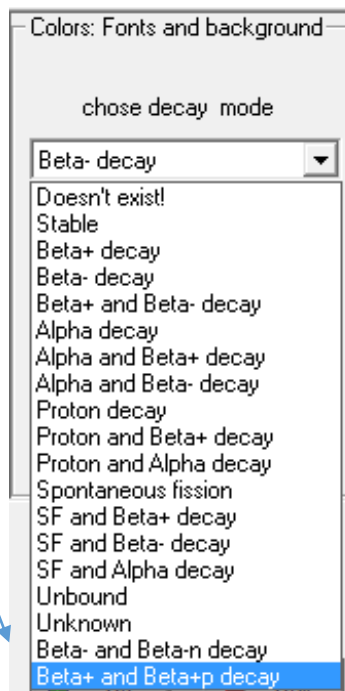
**1000 years
decay time**

Only stable residues





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

File Edit Options Help

```

2006 8.400000e-01
3006 4.950000e-01
3008 1.340000e-01
4008 9.950000e-01
4010 1.340000e-01
5008 9.973400e-01
5009 9.396000e-01
5010 3.200000e-03
5012 3.700000e-01
5014 2.820000e-01
    
```

Decay Branching Ratio

Z=17 (Chlorine)

A	decay1	branch. %	decay2	branch. %	T 1/2, s	Abundance, %
30	Unknown	100			8.430e-13	
31	Beta +	100			1.500e-01	
32	Beta +	100			2.980e-01	
33	Beta +	100			2.511e+00	
34	Beta +	100			1.527e+00	
35	Stable	100				75.760
36	Beta +	1.90	Beta -	98.10	9.503e+12	
37	Stable	100				24.240
38	Beta -	100			2.234e+03	
39	Beta -	100			3.372e+03	
40	Beta -	100			8.100e+01	
41	Beta -	100			3.840e+01	
42	Beta -	100			6.800e+00	
43	Beta -	100			3.130e+00	
44	Beta -	100			5.600e-01	
45	Beta -	76.00	Beta - n	24.00	4.130e-01	
46	Beta -	40.00	Beta - n	60.00	2.320e-01	
47	Beta -	100			1.010e-01	
48	Beta -	100			2.480e-02	
49	Beta -	100			1.890e-02	
50	Beta -	100			4.400e-03	
51	Beta -	100			6.180e-03	
53	Unknown	100			2.700e-03	
55	Unknown	100			8.600e-04	

T 1/2 : compilation of experimental and calculated values.
See the AME dialog for details

2D-Plot Databases Help

- AME & properties: View, Edit
- AME & properties: Plots
- Isomer database
- Ionization energy database
- Decay Branching Ratio database**

Isotopes

Chlorine

A Element Z
36 Cl 17

Table of Nuclides

Beta+ and Beta- decay Change

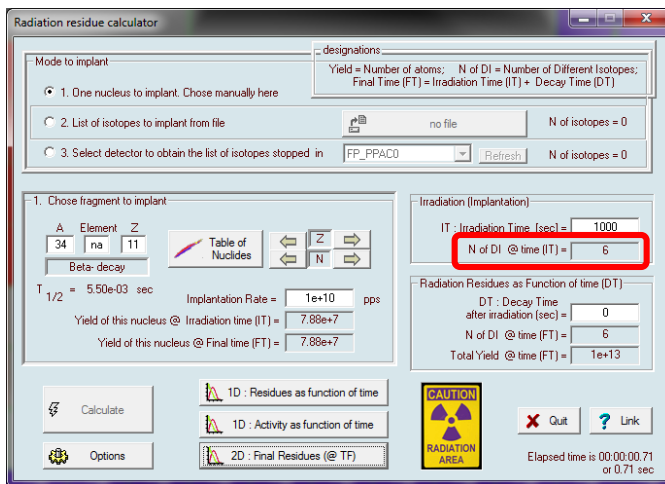
Branching

Beta + 1.9 %
Beta - 98.1 %

Save

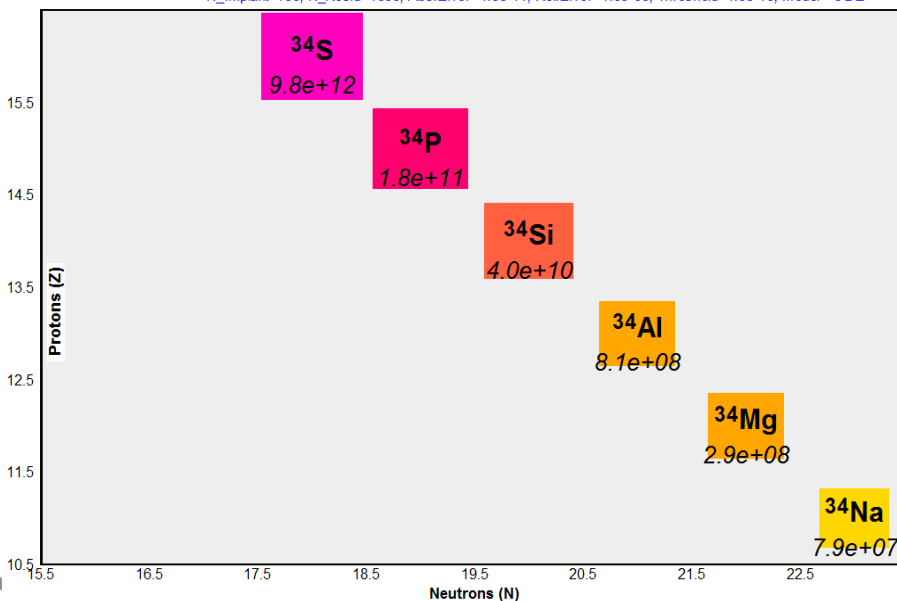
Generate Z-wallet Quit

v.9.10.331. No Decay Branch Database

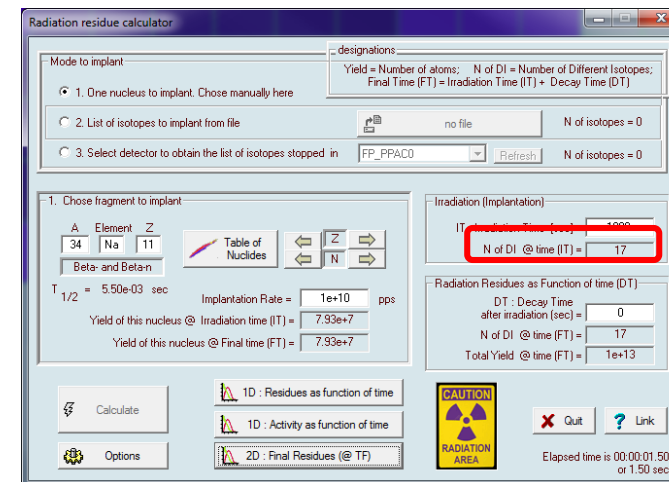


Radioactive decay residues

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"

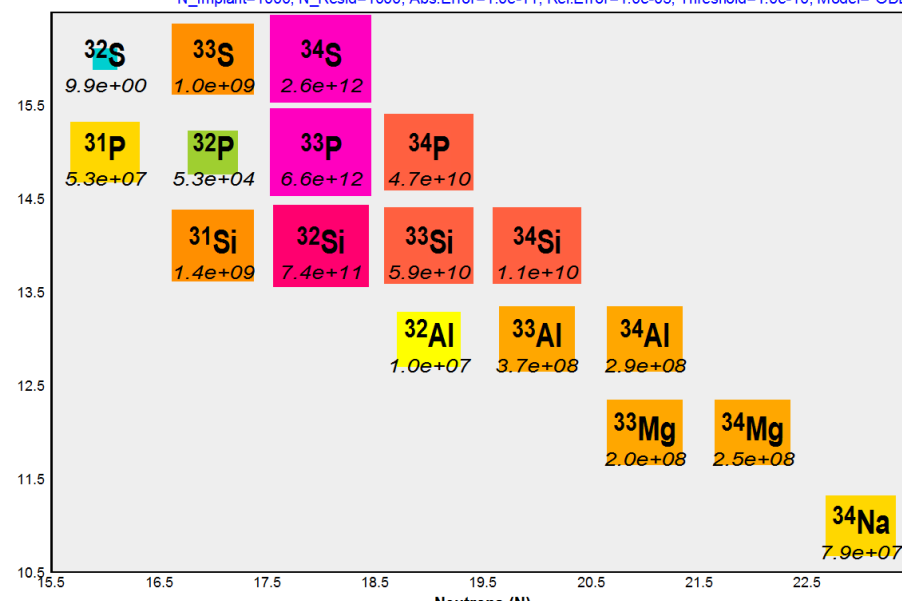


v.9.10.341. With Decay Branch Database



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=100, N_Resid=1000, Abs.Error=1.0e-11, Rel.Error=1.0e-03, Threshold=1.0e-10, Model="ODE"



1. Authors sent the e-mail with the source to implement in LISE⁺⁺
2. We discussed with the authors all moments recently for porting to C++ , the GUI shell creation, using in LISE⁺⁺ , citations and so on. They proposed to create a link on the LISE⁺⁺ site for ETACHA users

PHYSICAL REVIEW A **92**, 042703 (2015)

Extension of charge-state-distribution calculations for ion-solid collisions towards low velocities and many-electron ions

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⁴Laboratorio de Colisiones Atómicas, Instituto de Física Rosario (CONICET-UNR) and Facultad de Ciencias Exactas, Ingeniería y Agrimensura, Universidad Nacional de Rosario, Avenida Pellegrini 250, 2000 Rosario, Argentina

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Knowledge of the detailed evolution of the whole charge-state distribution of projectile ions colliding with targets is required in several fields of research such as material science and atomic and nuclear physics but also in accelerator physics, and in particular in regard to the several foreseen large-scale facilities. However, there is a lack of data for collisions in the nonperturbative energy domain and that involve many-electron projectiles. Starting from the ETACHA model we developed [Rozet *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. B* **107**, 67 (1996)], we present an extension of its validity domain towards lower velocities and larger distortions. Moreover, the system of rate equations is able to take into account ions with up to 60 orbital states of electrons. The computed data from the different new versions of the ETACHA code are compared to some test

1. Implementation of the ETACHA4 code to the LISE⁺⁺ package :
 - i. Porting from FORTRAN to C++
 - ii. Creation the ETACHA GUI shell for Windows OS
 - iii. Modify LISE⁺⁺ to use ETACHA.dll in LISE⁺⁺ transmission calculations
 - iv. *Update LISE.xls to provide ETACHA calculations in MS Excel (???)*
2. *Compare “LISE⁺⁺ ETACHA4” or (“ETACHA4 GUI”) results with the NSCL charge state measurement database (???)*

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

The screenshot shows the Visual Studio IDE with the ETACHA4.FOR source code open. A terminal window titled 'C:\buffer\ETACHA4_laptop\Debug\ETACHA4.exe' is overlaid on the code, displaying the following text:

```

Data used in previous calculation :
General data :
PROJECTILE: atomic number= 82. incident charge= 56. atomic mass=207.
incident energy= 28.900 MeV/u
TARGET: atomic number= 6. atomic mass= 12. density= 2.000 g/cm3
maximum target thickness (mg/cm2) = 5.000
minimum step (g/cm2) = 0.100E-01 maximum step= 200.
numerical uncertainties on output :
absolute= 0.1000E-03 relative= 0.1000E-03
Want to change any of these value? <No/y>
<Type 'y' to change
Type 'return' not to change>
  
```

The code in the background includes prompts for energy values and target data, such as 'This program needs two values of energy', 'You can choose one value close to the initial', and 'Change these values'.

ETACHA GUI in LISE⁺⁺ package

The code "ETACHA4" : Windows GUI (beta)

The screenshot shows the 'Utilities' menu in the LISE++ application. The menu items are: LISE++ for Excel, CODES: Charge, Global, PACE4, etc., Radioactivity, decays, Reactions utilities, and Plots: Energy loss, Ranges, Stragglings, etc. The 'CODES: Charge, Global, PACE4, etc.' sub-menu is open, showing options like 'Spectrometric Calculator by J.Kantele', 'The code "CHARGE"', 'The code "GLOBAL"', 'The code "ETACHA4"', and 'The code "GEMINI++ (GUI)'. The 'The code "ETACHA4"' option is highlighted with a blue box, and its sub-menu is also open, showing 'The code "ETACHA4" : Windows GUI (beta)' and 'The code "ETACHA4" : DOS-version'.

"About" window

ETACHA
 calculating charge state distributions
www.insp.iussieu.fr/ETACHA-a-code-to-predict-the.html
 E. Lamour, P. D. Fainstein, M. Galassi,
 C. Prigent, C. A. Ramirez, R. D. Rivarola,
 J.-P. Rozet, M. Trassinelli, and D. Verhert
 PHYSICAL REVIEW A 92, 042703 (2015)
 Version 4.L 2.130 BETA
 19-JUL-2016
 This program has been converted to C++ and ported to MS Windows GUI by O.B.Tarasov (NSCL/MSU) within the framework of the LISE++ program
lise.nsci.msu.edu

Main window

ETACHA 4 (GUI)
 File Help
 DOS version About
still under construction !!
Projectile
 A: 207, Element: Pb, Z: 82, Q: 60, Energy (MeV/u): 28.9, Stopping power (MeV/mg/cm2): 75.905
 Last orbital of: Neutral atom = 6 p 2, Ion in g.s. = 3 d 4
 Final Energy: 28.532, Final Stopping power: 76.335
 Use Energy Loss Calculations
Target
 A: 12.01, Element: C, Z: 6, Thickness: 1 mg/cm2, Density: 2.26 g/cm3
 5.014e+19 atoms/cm2
IONIZATION model
 CDW-EIS (default)
 PWBA (fast)
EXCITATION model
 Symmetric-Eikonal (default)
 PWBA (fast)
Corrections for PWBA (parameter "ibin")
 0 : empirical saturation correction (default)
 1 : binding correction included (not recommended)
 2 : no empirical correction and no binding correction
Integration model
 ODE (ordinary differential equation solver) ISBN: 0716704617
 RKF45 (Runge-Kutta-Fehlberg ODE solver)
 Intermediate output of cross sections
Steps & Numerical uncertainties
 Absolute = 1e-3, Relative = 1e-3
 Minimum step = 1 ug/cm2, Maximum step = 10 ug/cm2
Reaction characteristics
 perturbation parameter: Kp (n=1) = 0.1798, Kp (n=3) = 0.0200
 projectile velocity: Vp = 33.36 au
Show Results
 Event logs
 Q mean
 Cross Sections
 populations 1s-2p
 e- states: 00-09
 e- states: 10-19
 e- states: 20-29
 e- states: 30-39
 e- states: 40-49
 e- states: 50-59
ready
 10 to 19 EE- charge states in Eta1019.txt
 20 to 29 EE- charge states in Eta2029.txt
 30 to 39 EE- charge states in Eta3039.txt
 40 to 49 EE- charge states in Eta4049.txt
 50 to 59 EE- charge states in Eta5059.txt
 bare, 1s, 2s, 2p, 1s2, 1s2s, 1s2p, 1s2 2s, 1s2+2p ions and sum of these in ETAPIED.txt
 mean 1s, 2s, 2p, 3s, 3p and 3d populations in POPMEAN.txt
WARNING! Next calculation will overwrite these files
 Consider saving or renaming these results !
 FINAL achieved T=1.000 mg/cm2 <Q>=72.345 dQ=1.672 E=28.495 dSum=0.015

Intermediate output window of cross sections

ETACHA cross sections
Information

N	(sub)shell	Capture (MEC+REC)	IONization (includes n-4)	From / To	2s	2p	3s	3p	3d	n-4
1	1s	5.7635e-1	3.4763e-3	1s	3.7693e-3	6.3286e-3	6.1950e-4	9.2268e-4	7.8450e-5	5.5660e-4
2	2s	9.8725e-2	3.0829e-1	2s		6.8601e+0	1.3878e-1	1.3276e-1	4.9516e-1	1.4501e-1
3	2p	1.6881e-1	2.7578e-1	2p			1.4652e-2	1.6379e-1	6.1129e-1	1.4708e-1
4	3s	6.9094e-2	1.6077e+0	3s				2.5257e+1		4.5247e+0
5	3p	1.6954e-1	1.6077e+0	3p					1.1388e+1	5.0498e+0
6	3d	2.3890e-1	1.6077e+0	3d						5.9398e+0
7	n-4	9.2897e-1	3.9330e+0							

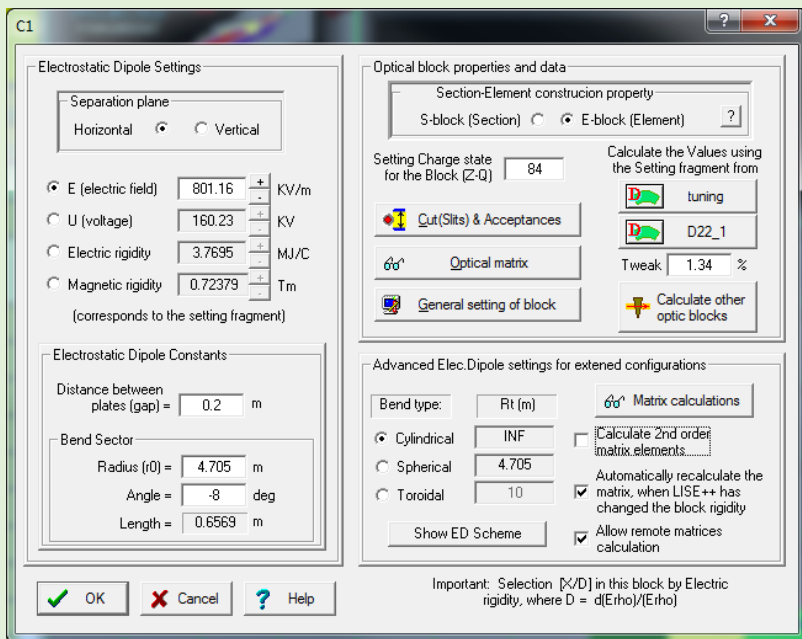
You can EDIT these cross sections

N	(sub)shell	MEC (capture)	REC (capture)	IONization	From / To	2s	2p	3s	3p	3d	n-4
1	1s	7.4753e-5	5.7628e-1	3.4763e-3	1s	3.7693e-3	6.3286e-3	6.1950e-4	9.2268e-4	7.8450e-5	5.5660e-4
2	2s	1.0215e-2	8.8511e-2	3.0829e-1	2s		6.8601e+0	1.3878e-1	1.3276e-1	4.9516e-1	1.4501e-1
3	2p	3.0644e-2	1.3817e-1	2.7578e-1	2p			1.4652e-2	1.6379e-1	6.1129e-1	1.4708e-1
4	3s	4.2868e-2	2.6225e-2	1.6077e+0	3s				2.5257e+1		4.5247e+0
5	3p	1.2860e-1	4.0938e-2	1.6077e+0	3p					1.1388e+1	5.0498e+0
6	3d	2.1434e-1	2.4563e-2	1.6077e+0	3d						5.9398e+0
7	n-4	9.0063e-1	2.8335e-2	3.9330e+0							

 Ionization: PWBA
 Excitation: PWBA
 207Pb (28.9MeV/u) + C
 Version 4
 All cross sections in 1e-20 cm2

Using 2nd order electrostatic dipoles in EMMA @ TRIUMF

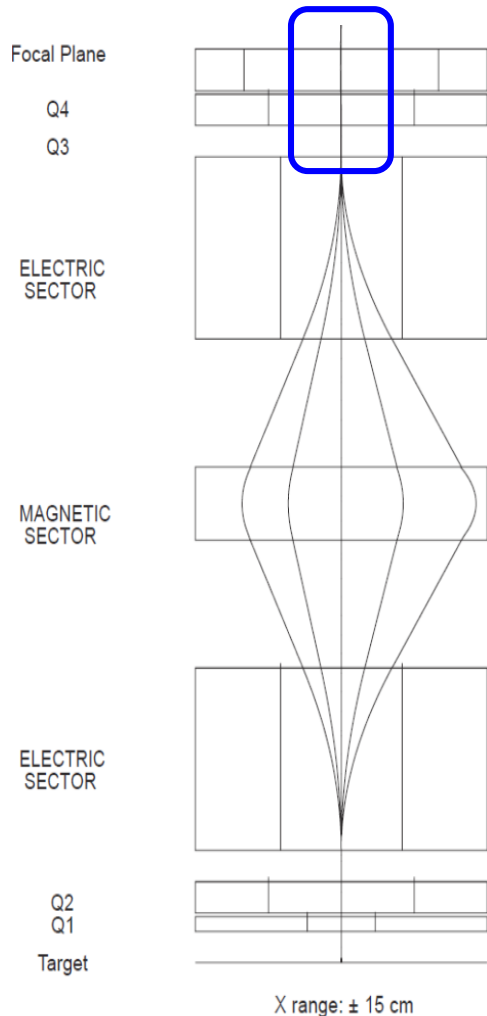
The 2nd order approximation equations in C-format were provided by Robert Hipple (Department of Physics and Astronomy, Michigan State University) based on H.Wollnik's work NIM 34 (1965) 213-221



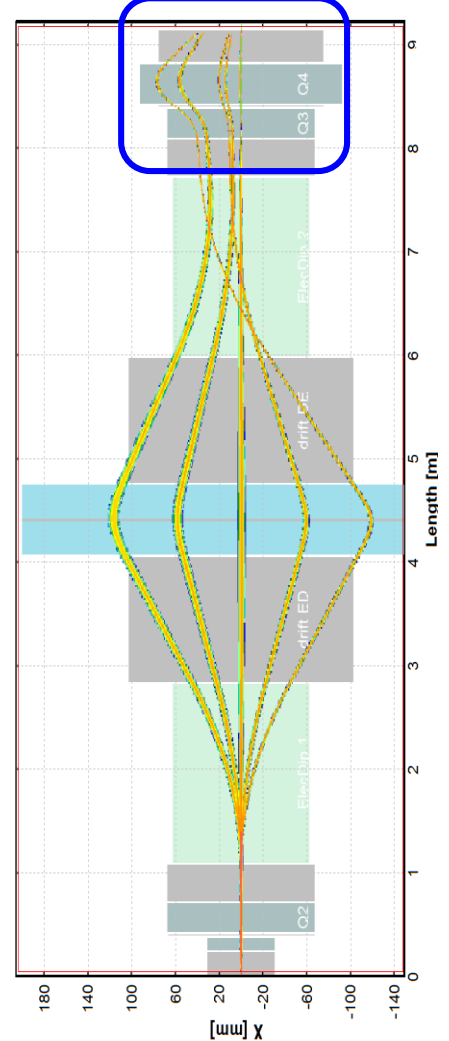
2nd order E.D. settings for already existed configuration

- 1st step: set "checked" the 2nd order box
- 2nd step: click "Matrix calculations" button
- 3rd step: Accept calculations

NIM A544 (2005) 565

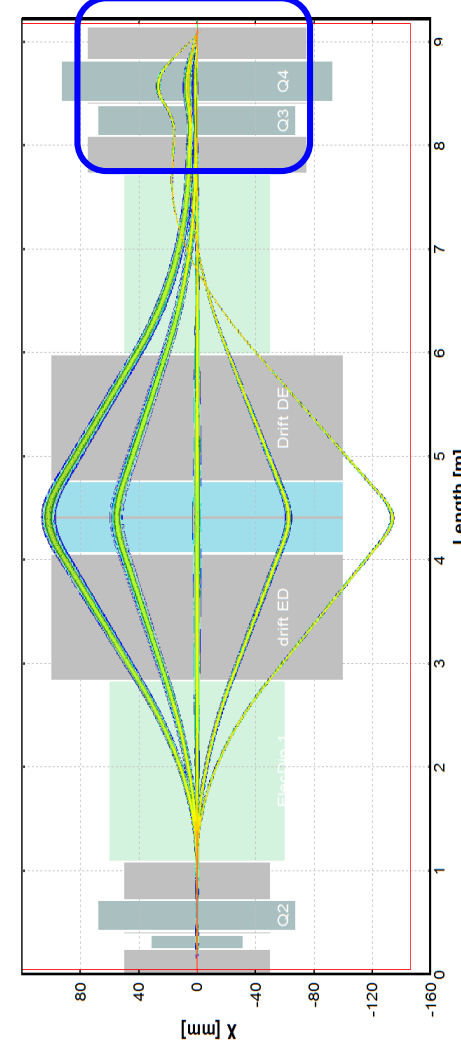


LISE++ v.9.10.207



2nd order

LISE++ v.9.10.296



2nd order

9.10.131 07/10/15

- Ionization Energy Database
- Ion mass Calculator
- Ion mass corrections on electron binding energy
(set default to use in LISE++)

$^{238}\text{U}^{92+}$ 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**

Ion Mass Calculator / Ionisation Energy Database

A	Element	Z
238	u	92
Stable		

Table of Nuclides

← Z →
← N →

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.

$M(A,Z,Q) = M(A,Z) - Q * m_e + TBE(0) - TBE(Q)$

IsoSeq -- 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 X Quit

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

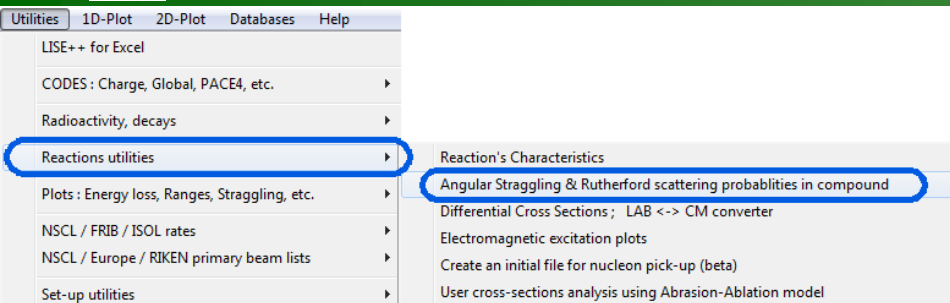
LISE for Excel new function

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

Function Arguments

Formula result = 238.0453022

OK Cancel



These $P=f(\text{angle})$ and $E=f(\text{angle})$ functions will be used in the Monte Carlo mode for the primary beam transmission calculations

Angular straggling \equiv multiple scattering through small angles

How distinguish in Monte Carlo simulations ?

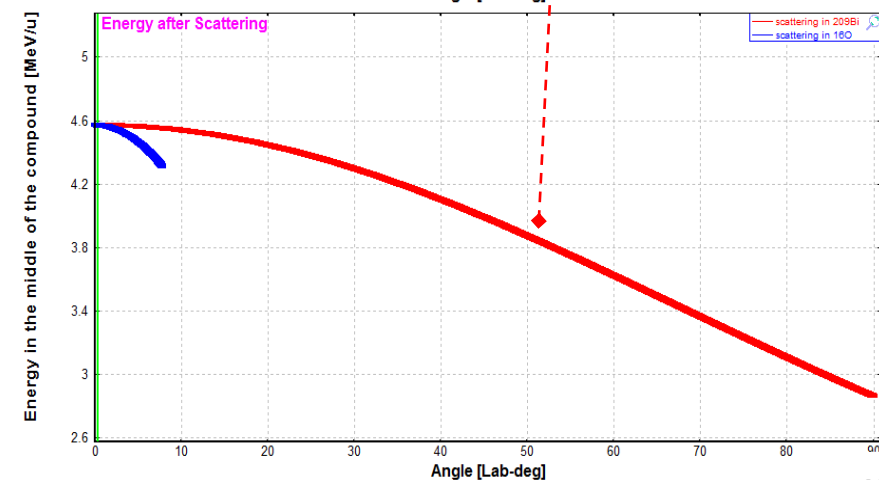
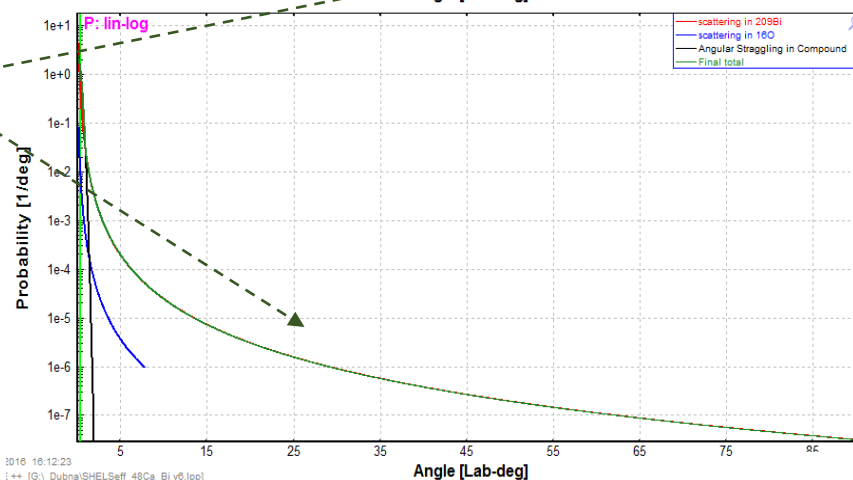
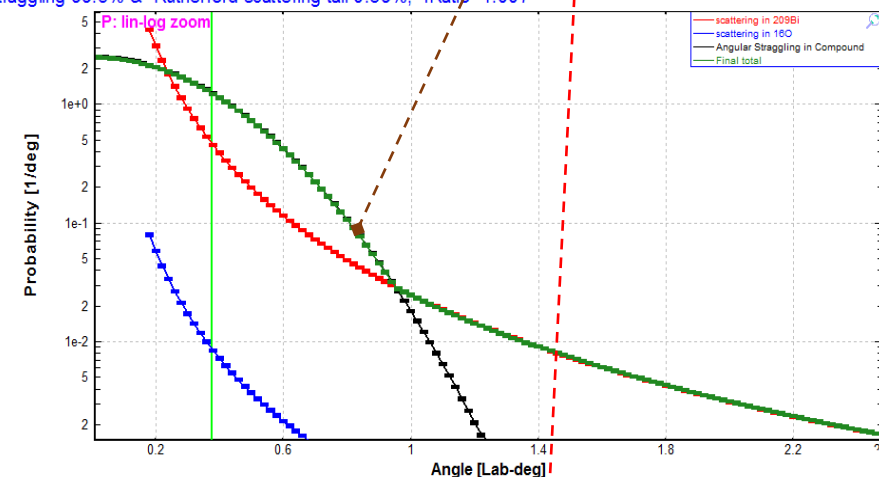
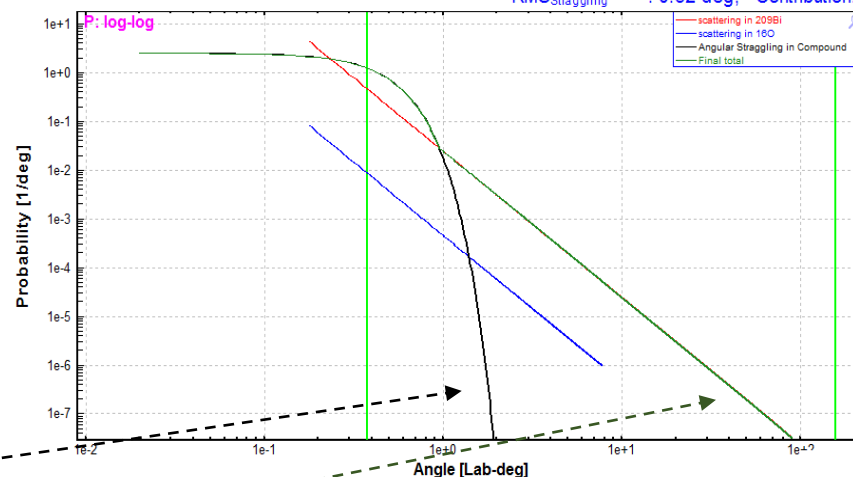
- Angular straggling (small angles)
- Rutherford scattering (large angles)

The nature is one for both processes. It is necessary to have only one probability distribution for scattering process through a material segment.

Good benchmarks for angular straggling models!!
(Should be double crossing)

Angular Straggling & Rutherford scattering probabilities in compound

^{48}Ca (4.61 MeV/u) + BiO_2 (0.4 mg/cm²)
Grazing & maximum kinematic angles (in degrees) @ middle of material: [0] ^{209}Bi : 156.9 & 180.00; [1] ^{16}O : 7.8 & 19.48
RMS_{Straggling}^{SP308}: 0.32 deg; Contribution: Straggling 99.3% & Rutherford scattering tail 0.69%; IRatio=1.007



Created By product of the Fusion reaction update and
The "Rutherford scattering and Angular straggling" utility

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

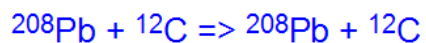
For Kinematics Plots use energy values

- after reaction
- at entrance of detectors

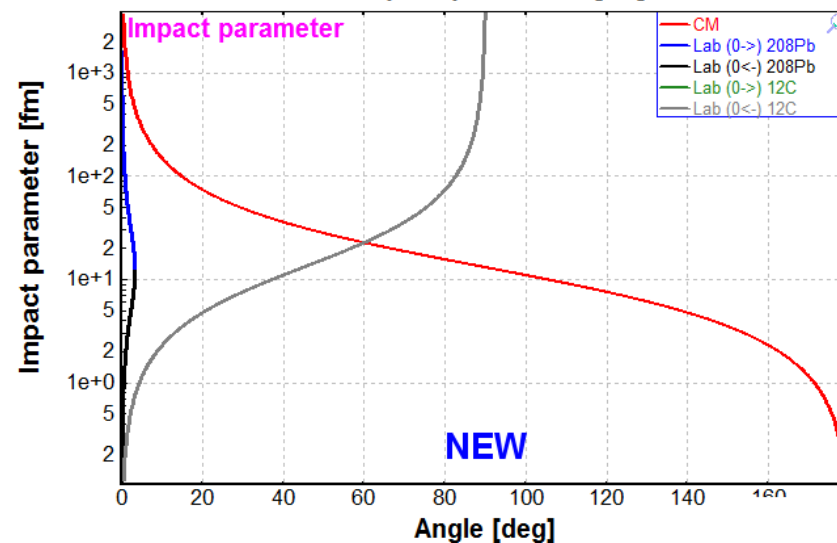
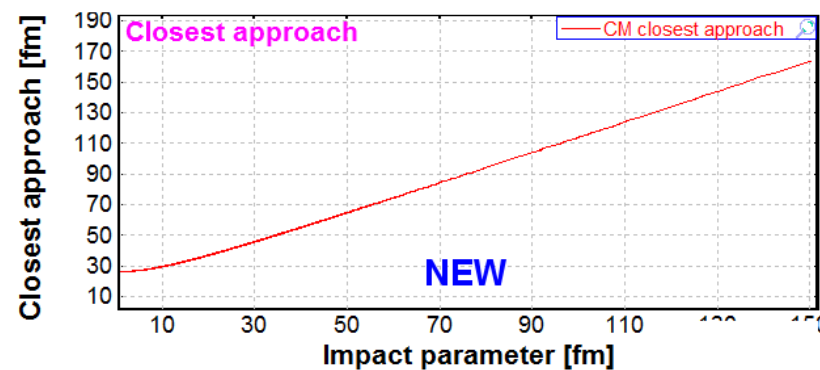
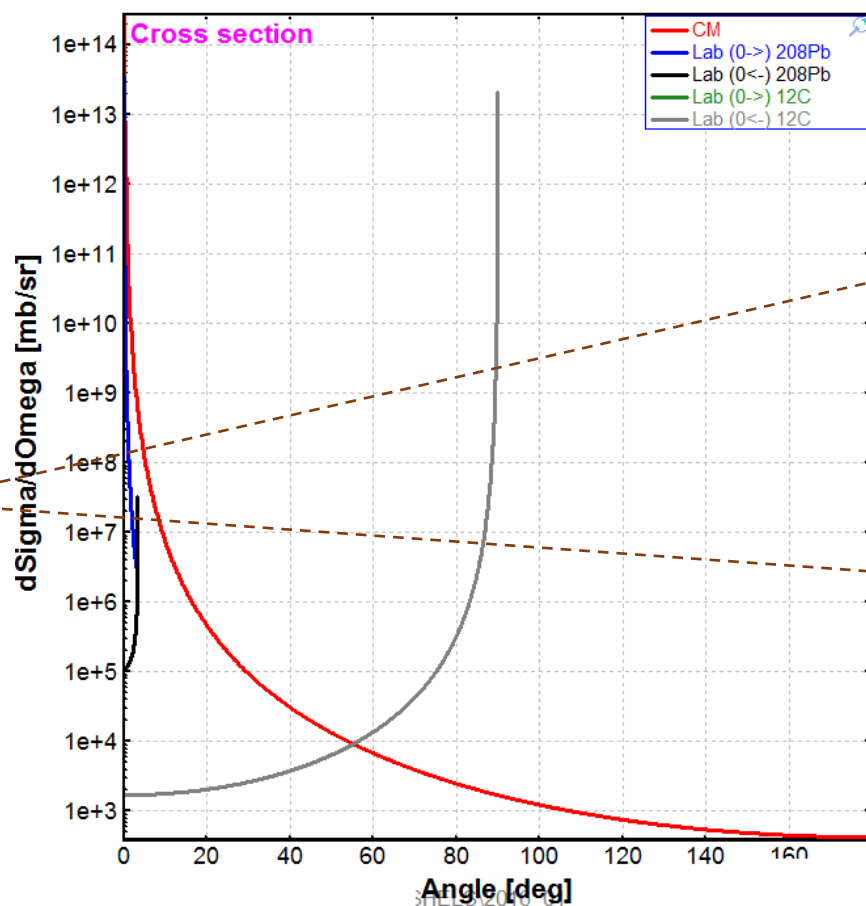
Kinematics plots

Rutherford plot

Rutherford scattering



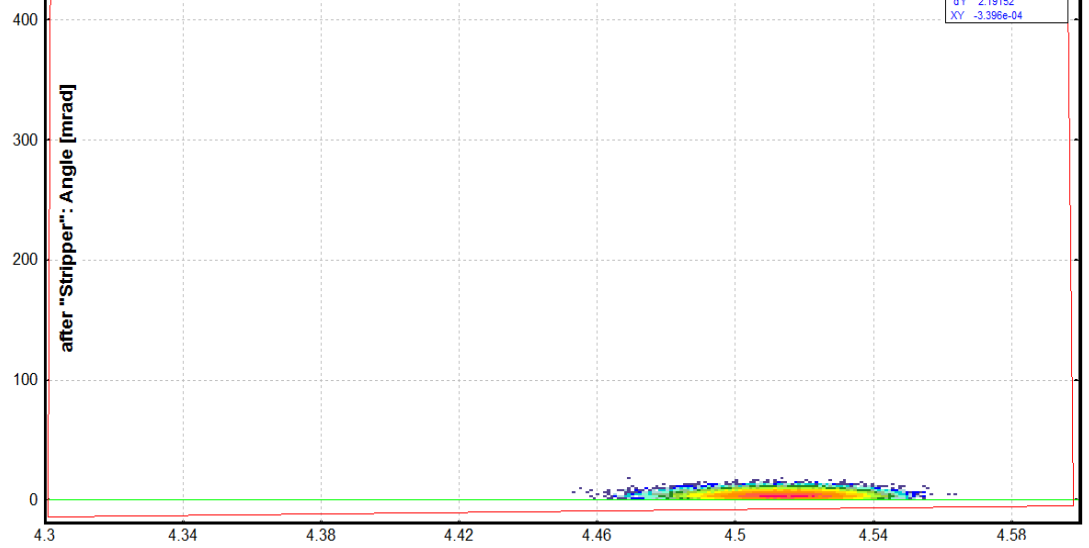
Projectile Energy at the reaction place: 2.39 MeV/u



Light beam & heavy target

Primary beam scattering in target (MC)

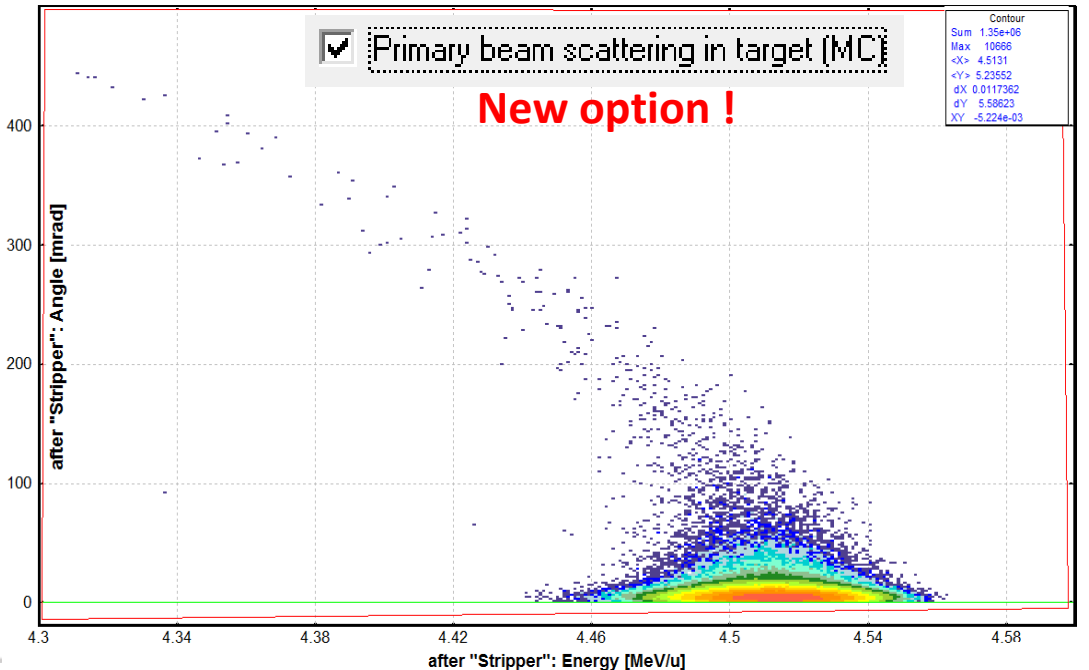
Contour
Sum 1.15e+05
Max 1419
<X> 4.51389
<Y> 3.61372
dX 0.0116178
dY 2.19152
XY -3.396e-04



Primary beam scattering in target (MC)

New option !

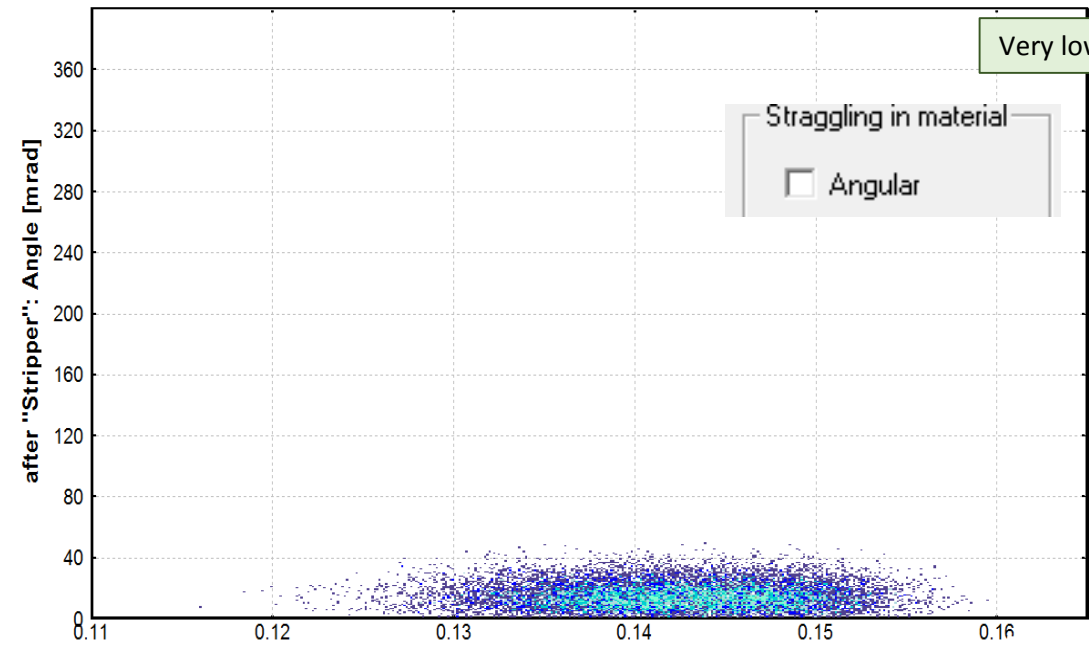
Contour
Sum 1.35e+06
Max 10666
<X> 4.5131
<Y> 5.23552
dX 0.0117362
dY 5.59623
XY -5.224e-03



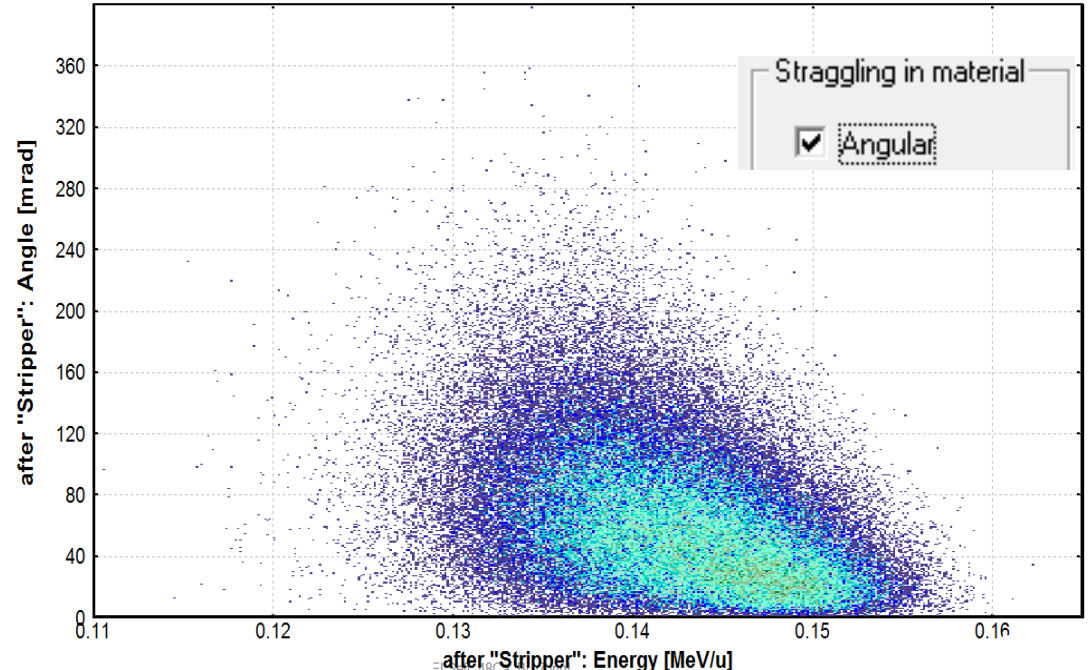
Primary beam (^{48}Ca)

Very low energy

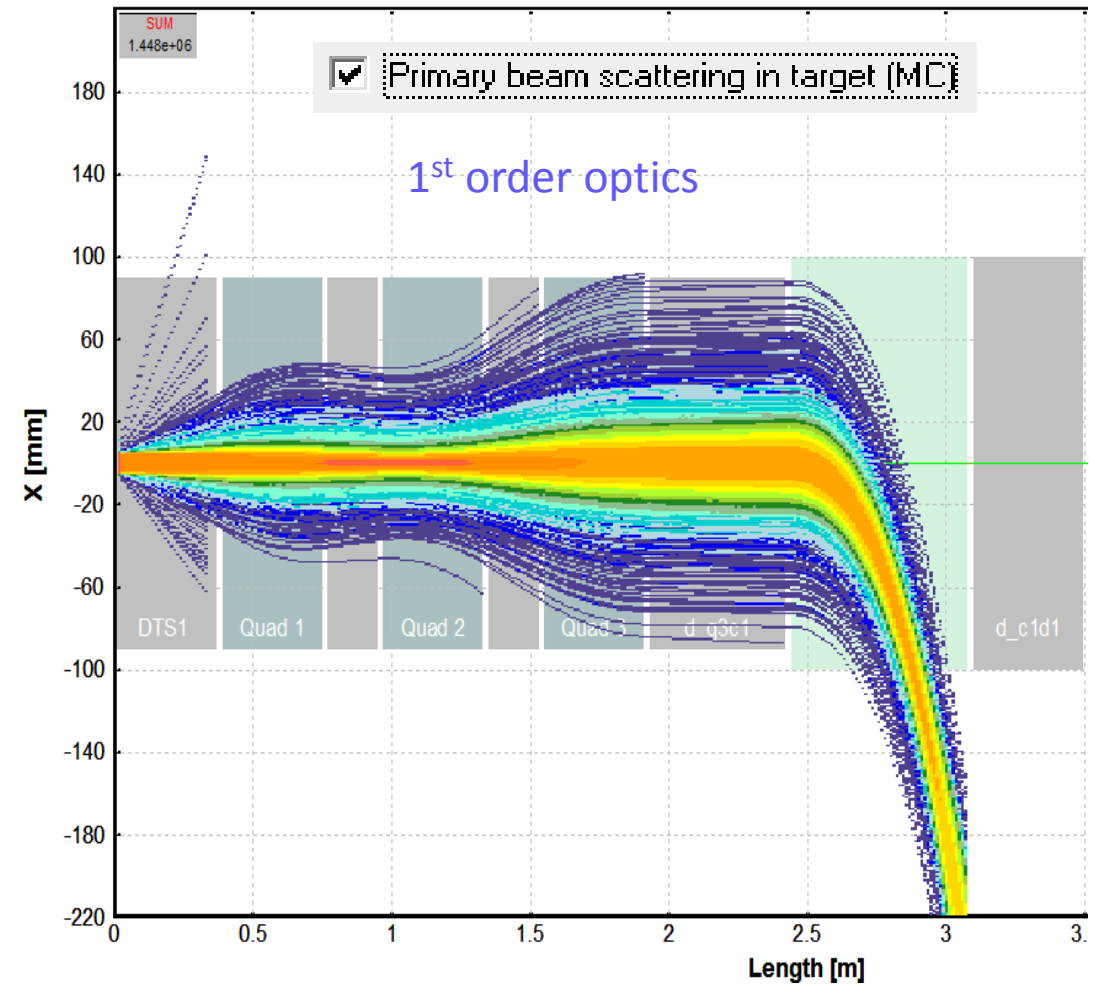
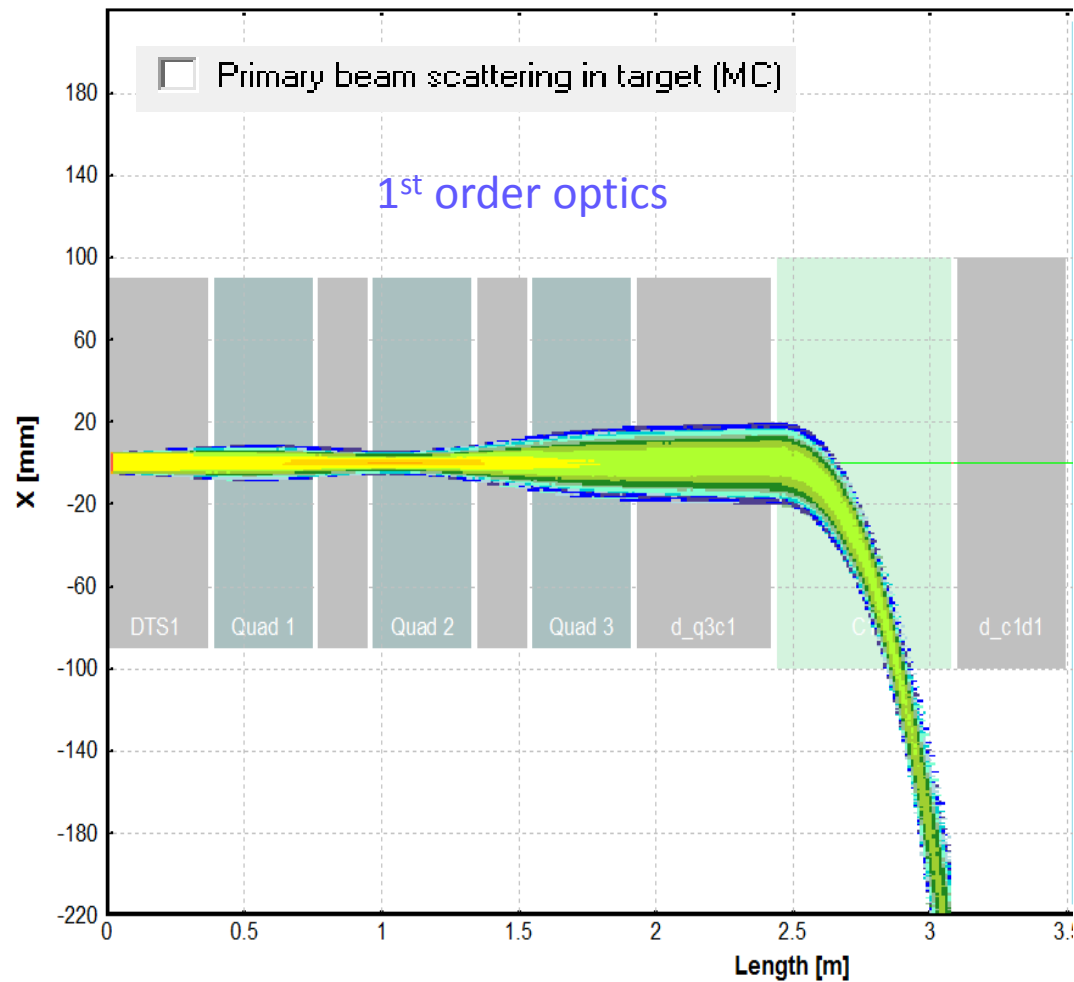
Straggling in material
 Angular



Straggling in material
 Angular



Setting ions ($^{255}\text{Lr}^{**+}$)



CONSTRUCTION OF EXTENDED CONFIGURATIONS

Extended Configurations v.9.9

- Fragment Separator “**BigRIPS**” @ RIKEN
- Spectrometer “**MSP144+Q2**” @ FLNR/JINR
- Recoil separator “**SHELS**” @ FLNR/JINR
- Spectrometer “**PRISMA**” @ LNL/INFN
- Fragment separator “**MARS**” @ TAMU (global revision)

Extended Configurations v.9.10

- Recoil separator “**EMMA**” @ TRIUMF
- Recoil separator “**FMA**” @ Argonne NL
- Recoil separator “**S³**” @ GANIL
- Recoil separator “**SECAR**” @ MSU
- Recoil separator “**DRAGON**” @ TRIUMF
- Recoil separator “**SHELS**” @ FLNR/JINR (global revision)
- Fragment separator “**ACCULINNA2**” @ FLNR/JINR (global revision)
- **HRS** : A High Rigidity Spectrometer for FRIB

Mostly
low-energy
devices

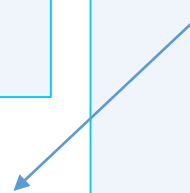
Recoil separator “**DRAGON**” @ TRIUMF

High Order extended configuration

Version 9.10.142
from 07/22/2015

[Link: Spectrometer “DRAGON” \(TRIUMF\)](#)

- DRAGON2000 extended configuration
 - DRAGON documentation
 - DRAGON files location
 - Optimization with LISE++
 - Alternative configuration
 - 2015 settings vs. documentation 2000
- Angular Acceptance
- Momentum Acceptance
- Charge states selection
- Experiment $^{15}\text{O}(\alpha, \gamma)^{19}\text{Ne}$
 - Fusion
 - De-excitation by gamma at low energies vs. kinematics
- Segmented configuration
- Open questions



- Recoil separator "EMMA" @ TRIUMF
- Recoil separator "FMA" @ Argonne NL
- S3 separator @ GANIL
- Recoil separator "SECAR" @ MSU
- Recoil separator "DRAGON" @ TRIUMF
- Recoil separator "SHELS" @ FLNR/JINR
- Fragment separator "ACCULINNA2" @ FLNR/JINR

- ❑ EMMA extended configuration
 - Documentation
 - EMMA files location
 - Optics
 - Optimization
- ❑ Angular Acceptance
- ❑ Momentum Acceptance
- ❑ Benchmarks
- ❑ Charge state selection
- ❑ LISE++ analytical and MC envelopes
- ❑ Reaction $d(^{132}\text{Sn}, p)^{133}\text{Sn}$

- ❑ DRAGON2000 extended configuration
 - DRAGON documentation
 - DRAGON files location
 - Optimization with LISE++
 - Alternative configuration
 - 2015 settings vs. documentation 2000
- ❑ Angular Acceptance
- ❑ Momentum Acceptance
- ❑ Charge states selection
- ❑ Experiment $^{15}\text{O}(\alpha, \gamma)^{19}\text{Ne}$
 - Fusion
 - De-excitation by gamma at low energies vs. kinematics
- ❑ Segmented configuration
- ❑ Open questions

- ❑ SECAR extended configurations
 - SECAR documentation
 - SECAR phase1
 - LISE++ modifications for SECAR
 - SECAR files location
 - SECAR phase 1 with COSY maps
 - Optimization with LISE++
- ❑ SECAR phase1: Angular Acceptance
- ❑ SECAR phase1: Momentum Acceptance
- ❑ SECAR phase1: Charge states selection
- ❑ Experiment $^{15}\text{O}(\alpha, \gamma)^{19}\text{Ne}$
 - Fusion
 - De-excitation by gamma at low energies vs. kinematics
- ❑ Segmented configuration
- ❑ Open questions

- ❑ FMA extended configuration
 - Documentation
 - FMA files location
 - Optics
 - Optimization
- ❑ Angular Acceptance
- ❑ Momentum Acceptance
- ❑ Experiment $^{32}\text{S} (115 \text{ MeV}) + ^{58}\text{Ni}$
- ❑ Open questions

Creation of Extended Configuration is not only LEGO-construction with LISE++ blocks!!!













1. Introduction
2. Segmented configurations
3. Extended: Geometry, Corrections
4. Optimization
5. S³ acceptances
6. Outlook

- ❖ Introduction
- ❖ Effective lengths
 - ✓ Quadrupoles
 - ✓ Dispersive elements
- ❖ Dispersive elements settings
 - ✓ Electrostatic dipoles C1 and C2
 - ✓ Magnetic dipoles D22_1 and D22_2
 - ✓ Magnetic dipole D8
- ❖ Apertures & Slits
- ❖ Calibrations

"SHELS"

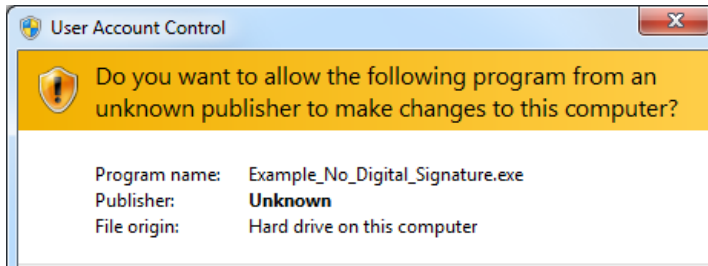
- ❖ Reaction choice
 - ✓ Charge state model
 - ✓ Fusion residual (SHE region)
- ❖ Configurations
 - ✓ Experimental (logbook) settings
 - ✓ Brho values by LISE++
 - ✓ Q5 field value modification
 - ✓ Obtaining angular acceptance
 - ✓ Final version for the LISE++ package
- ❖ Angular acceptance
- ❖ Beam suppression

Conference and Workshop presentations based on the LISE⁺⁺ code development (2013-2016)

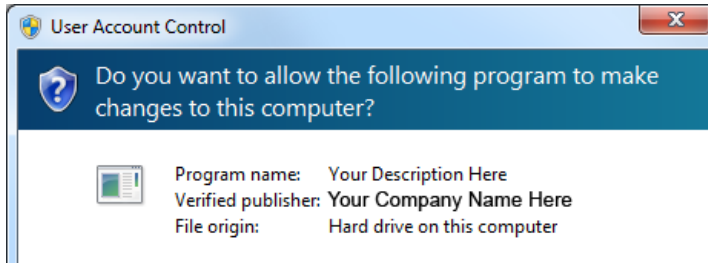
Ref	Date	Title, Contents	Presentation place
 PDF Adobe	17-19.08.2016	Predictions of Isotope Production Yields with LISE⁺⁺	East Lansing, MI, USA FRIB Workshop on Isotope Harvesting
 PDF Adobe	10.08.2016	Nuclear Data Needs for LISE⁺⁺	University of Notre Dame, South Bend, IN, USA Workshop for Nuclear Data Needs and Capabilities for Basic Science, Low Energy Community Meeting
 PDF Adobe	01-04.09.2015	Production of neutron-rich isotopes <i>LISE⁺⁺ reaction mechanism discussions, examples prepared with the LISE⁺⁺ code</i>	ECT*, Trento, Italy Interfacing Structure and Reaction Dynamics in the Synthesis of the Heaviest Nuclei
 PDF Adobe	31.03-02.04.2015	Recoil separator "SECAR" configurations in the LISE⁺⁺ package	MSU, East Lansing, USA SECAR collaboration meeting @ Low Energy Workshop
 PDF Adobe	11.05-15.05.2015	LISE⁺⁺ : Exotic Beam Production with Fragment Separators and Their Design	Grand Rapids, USA EMIS conference
 PDF Adobe	11.05-15.05.2015	Plans for Performance and Model Improvements in the LISE⁺⁺ Software <i>presented by M.Kuchera</i>	Grand Rapids, USA EMIS conference
 PDF Adobe	13.04-17.04.2015	Updating the LISE⁺⁺ Software and Future Upgrade Plans <i>presented by M.Kuchera</i>	Okinawa, Japan 21st Conference on Computing in High Energy and Nuclear Physics (CHEP)
 PDF Adobe	31.03-02.04.2015	Use LISE⁺⁺ for heavy ion reactions at low energy	TAMU, College Station, USA Super Heavy Nuclei International Symposium
 PDF Adobe	7-11.10.2014	Rare isotope beams production using fusion-fission reactions <i>LISE⁺⁺ fusion reaction mechanism update</i>	Waikoloa, Hawaii, USA Fourth Joint Meeting of the Nuclear Physics Division of APS and JPS
 PDF Adobe	8-13.09.2014	Projectile fragmentation as a tool to observe shell effects close to the neutron drip-line <i>LISE⁺⁺: Initial prefragments mechanism study, Abrasion-Ablation, dB E-systematics</i>	Kaliningrad, Russia International symposium EXON
HTML	8-13.09.2014	Production of Fast Rare Ion Beams <i>including examples of how to use the LISE⁺⁺ code</i>	Dubna, Russia Euroscool on Exotic Beams 2013
 PDF Adobe	10-12.12.2013	LISE⁺⁺ : Modeling Exotic Beam Production with Fragment Separators	RIKEN, Japan 5th Fragment-Separator Experts Meeting
 PDF Adobe	10-12.12.2013	Measurement of production cross sections and momentum distributions at MSU <i>LISE⁺⁺: Production cross section and momentum distribution models</i>	RIKEN, Japan 5th Fragment-Separator Experts Meeting

http://lise.nscl.msu.edu/paper/LISE_presentations.htm

Without signing certificate



With signing certificate

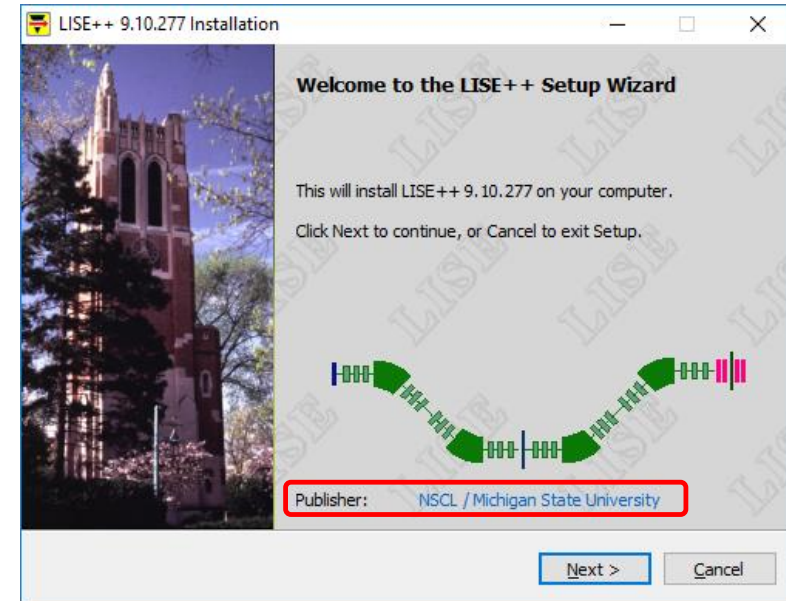


How to bypass the warning "Unknown Publisher" when executing a setup file?

To remove the "Unknown Publisher" security warning from your setup file, you need to [digitally sign](#) this file with your code signing certificate.

We need NSCL/FRIB signing certificate for LISE++ installation

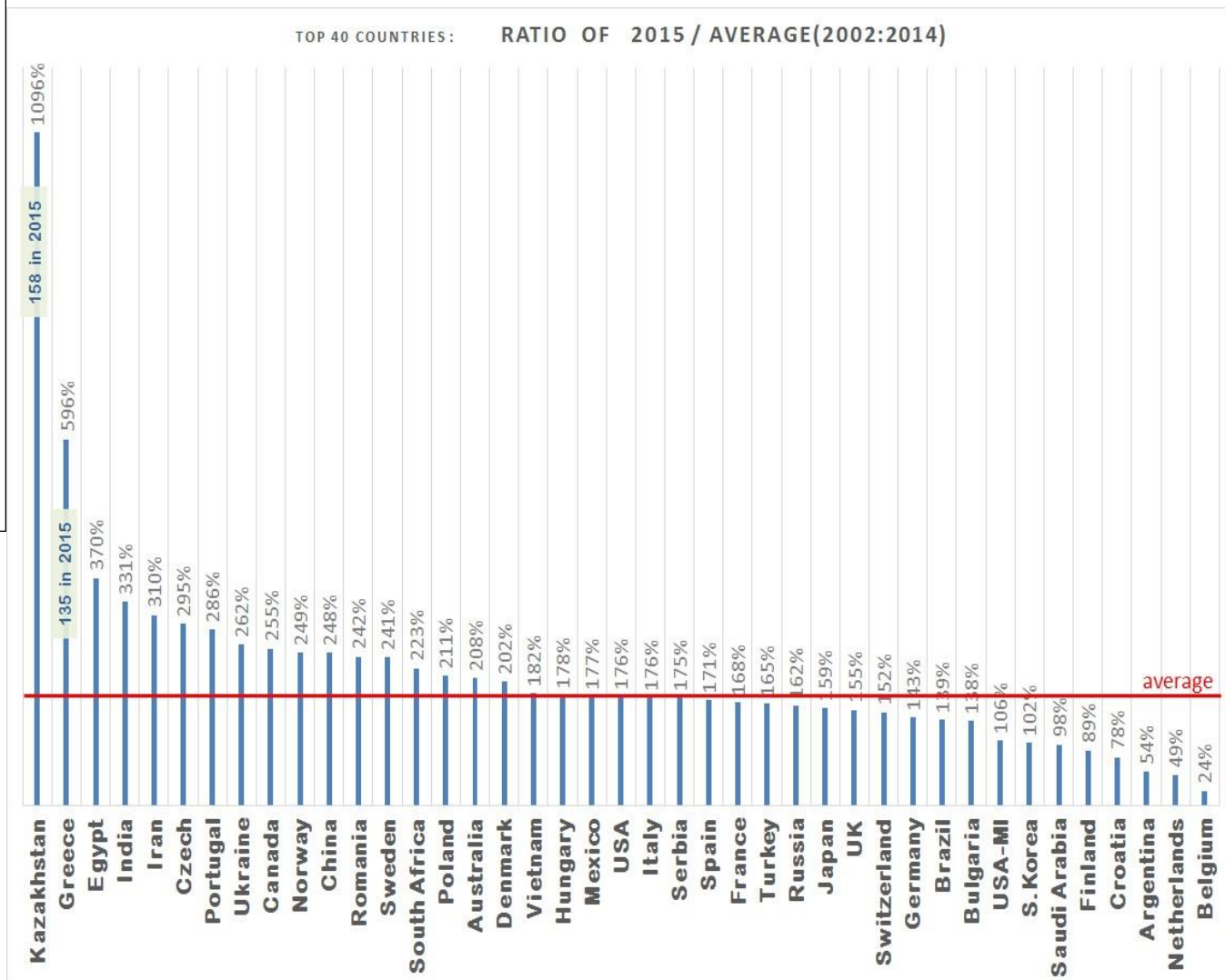
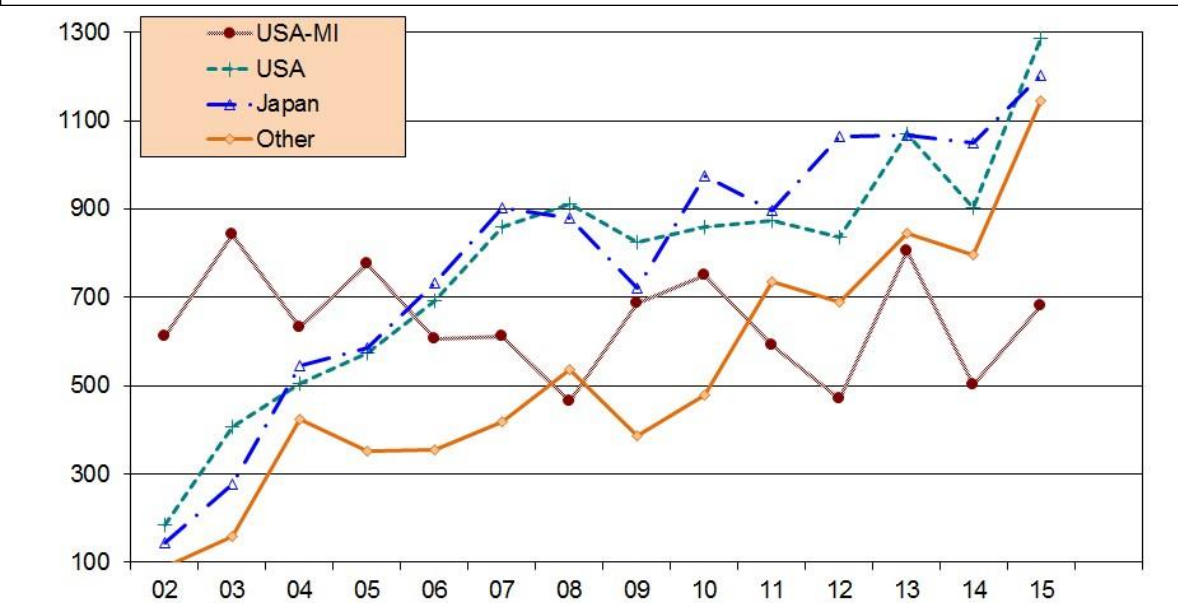
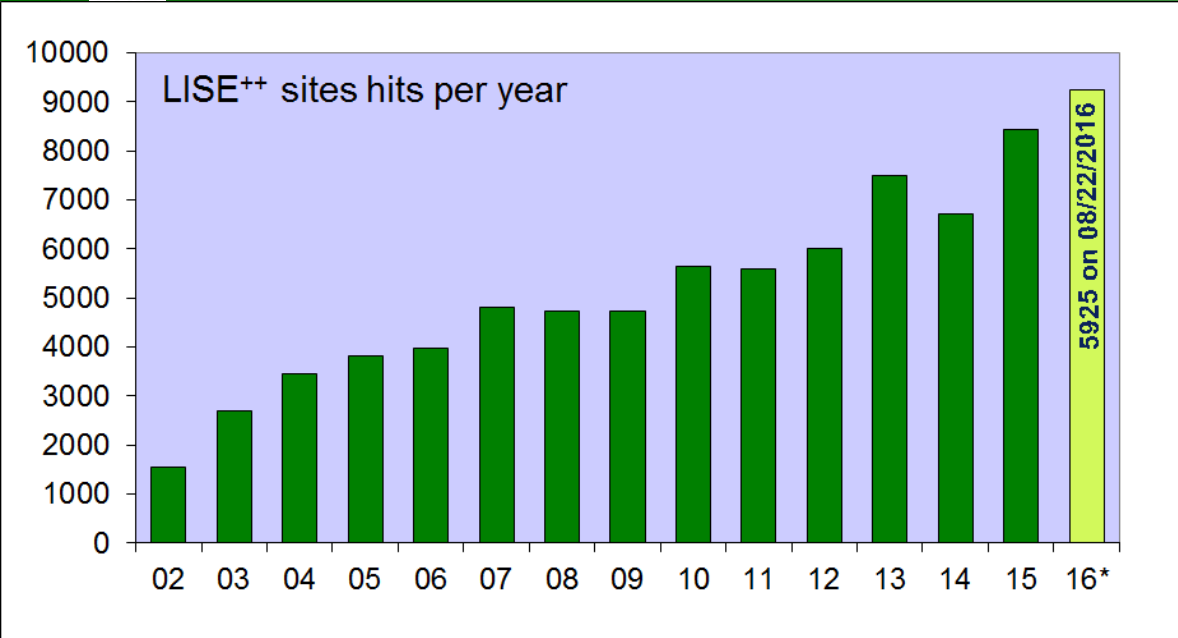
LISE++ installation

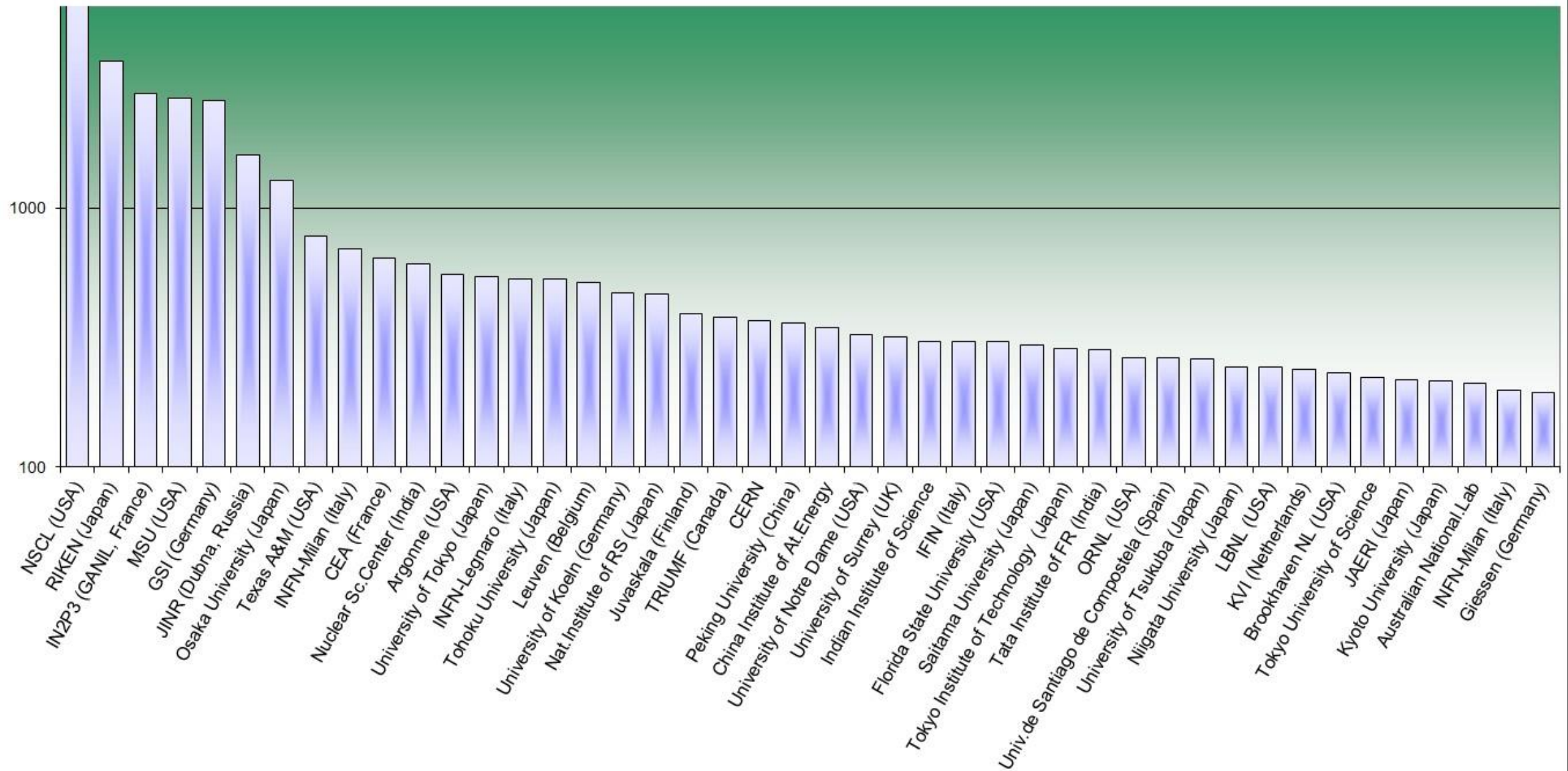


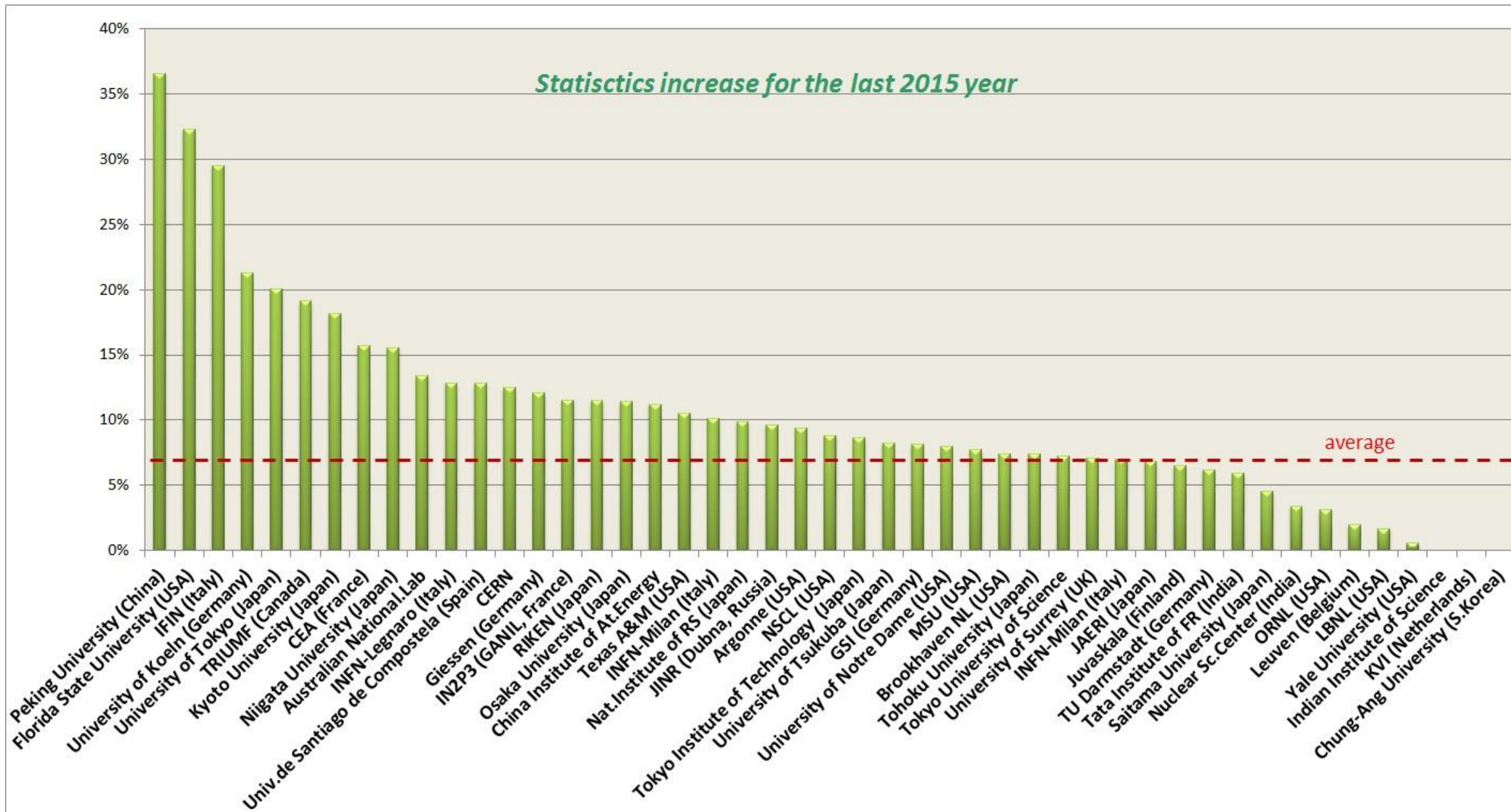
Settings → System → Apps & Features

Notifications & actions	LISE Qt Utilities NSCL / Michigan State University	72.3 MB 4/10/2016
Apps & features	LISE++ NSCL / Michigan State University	59.5 MB 2/3/2016
Multitasking		

1. Revision (and Creation) of extended configurations in the package (NSCL configurations - 1st priority)*
2. Preparation of documentation for the new official version 10
3. *Digital signing certificate*
4. Release of version 10 after benchmarking by the A1900 FS group (this fall)
5. LISE⁺⁺ development will be frozen with the Borland compiler.
Only urgent modifications to fix important issues.







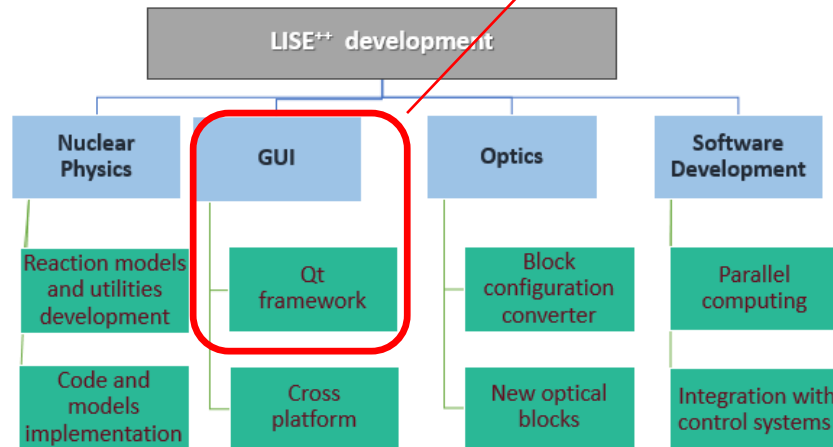
Plans for Performance and Model Improvements in the LISE⁺⁺ Software

EMIS

O.B. Tarasov, M.P. Kuchera, D. Bazin, B.M. Sherrill, K.V. Tarasova
National Superconducting Cyclotron Laboratory, Michigan State University

LISE⁺⁺ Development Plans

The LISE⁺⁺ software package will be transported to a modern graphics framework with new compilers to aid in the performance and sustainability of the code. To accommodate user diversity, LISE⁺⁺ will be adapted for cross-platform compatibility. The computational demands associated with more complicated devices at new large scale facilities should be addressed. In order to perform the necessary calculations in an acceptable time, code optimization and parallel methods will be applied. New features such as optimization, for example, of ion optics, improvements in reaction models, and new event generator choices are planned. Finally creation of a LISE⁺⁺ interface with control systems is envisioned.



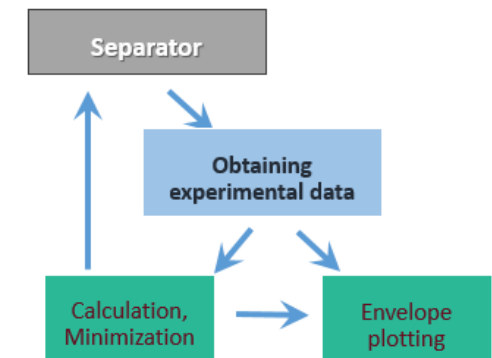
Development scheme for the LISE⁺⁺ update. The plan is to first do a graphics framework transportation, verify the new code, then implement improvements and new features.

Software Development

Qt framework : The LISE⁺⁺ program will be transported to a modern graphics framework for compatibility with future operating systems. Benefits include provisions for 64-bit operation, cross-platform compatibility, and the ability to take advantage of computational advances. Qt was chosen as the graphics framework based on its cross-platform capabilities, large feature set, and widespread use in cross-platform C++ applications.

Parallel computing : To take advantage of modern computing architecture, parallel computing methods are essential in achieving faster computation. Once transportation of LISE⁺⁺ to the Qt graphics framework is complete, we will be able to implement parallel computing on personal computers using OpenMP. In the future, large-scale calculations using supercomputers or many-core machines using MPI is also planned.

Integration with control systems : In order to directly assist the tuning of a separator, the LISE⁺⁺ program will be integrated with control systems. This will be tested at labs such as NSCL and GSI.



[Overview](#)[Utilities ▾](#)[Download](#)[Team](#)

The LISE⁺⁺ Transportation Team

Members working on the transportation of the LISE⁺⁺ Software Suite to Qt.

Michelle Kuchera

Research Associate
National Superconducting Cyclotron Laboratory
Michigan State University

[Website »](#)

Ksenia Tarasova

Technical Aide
National Superconducting Cyclotron Laboratory
Michigan State University

Post-doc,
who already left us...

Partial time,

With personal long
time breaks

Webmaster [Michelle Kuchera](#)



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This material is based upon work supported by the
Department of Energy National Nuclear Security
Administration under Award Number: DE-NA0000979
through the Nuclear Science and Security Consortium.
[Disclaimer.](#)



Last modified: Thu Jul 2 16:50:08 EDT 2015

1. Platform selection, development of a transition strategy
2. Establishment of GIT for the software development of many programmers
3. LISE⁺⁺ porting site
4. Porting LISE⁺⁺ utilities to Qt
5. Cross-platforms (Windows, MAC, Linux):
 - * build of executable codes
 - * installation package creation
6. Creation of the executable shell for LISE⁺⁺ Qt utilities
7. LISE⁺⁺ code porting (in process)



Documentation

- Introduction
- PACE4 In Action
- Tutorials
 - Beginner
 - Intermediate Topics
- References

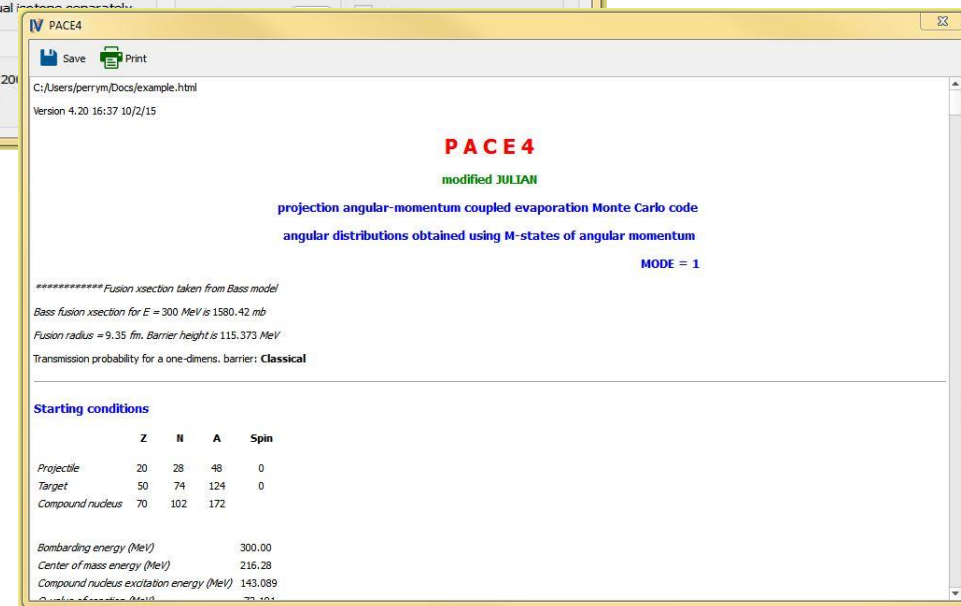
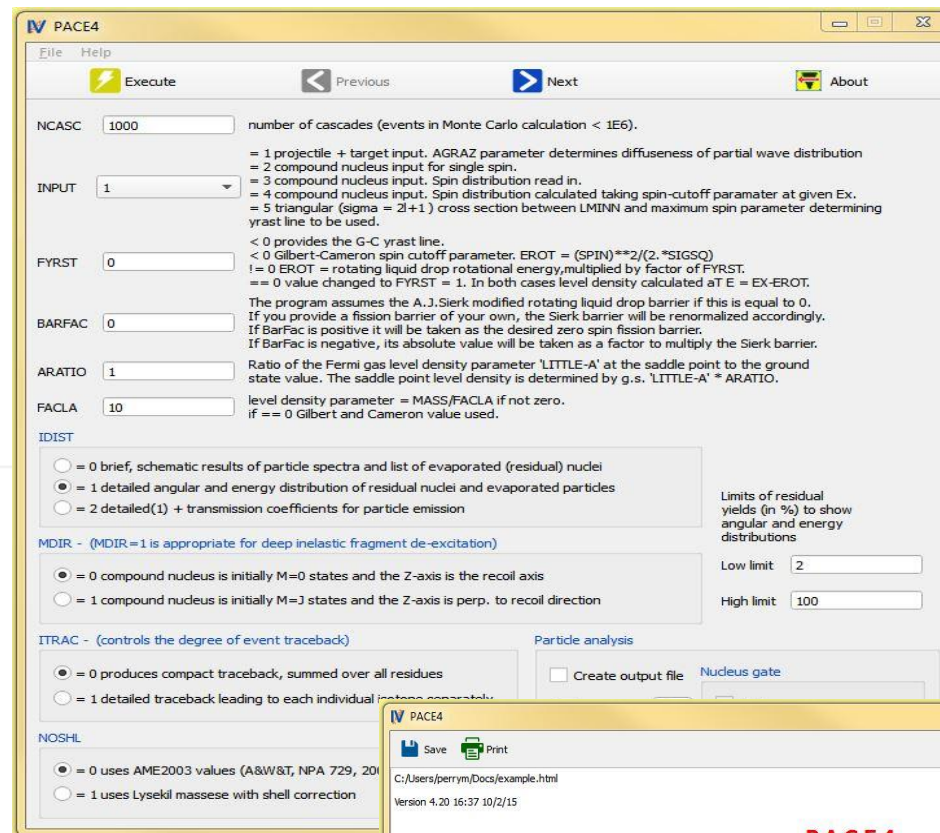
Introduction

PACE4 has been ported from Borland to Qt within the LISE++ framework [1]. The code PACE [2] is a modified version of JULIAN-the Hillman-Eyal evaporation code using a Monte-Carlo code coupling angular momentum.

The version of PACE4 now distributed in the Utilities Package uses an updated mass table from 2013. Previous versions of PACE4 used a mass table from 2003.

[1] http://lise.nscf.msu.edu/5_13/lise_5_13.html

[2] A.Gavron, Phys.Rev. C21 (1980) 230-236;





Documentation

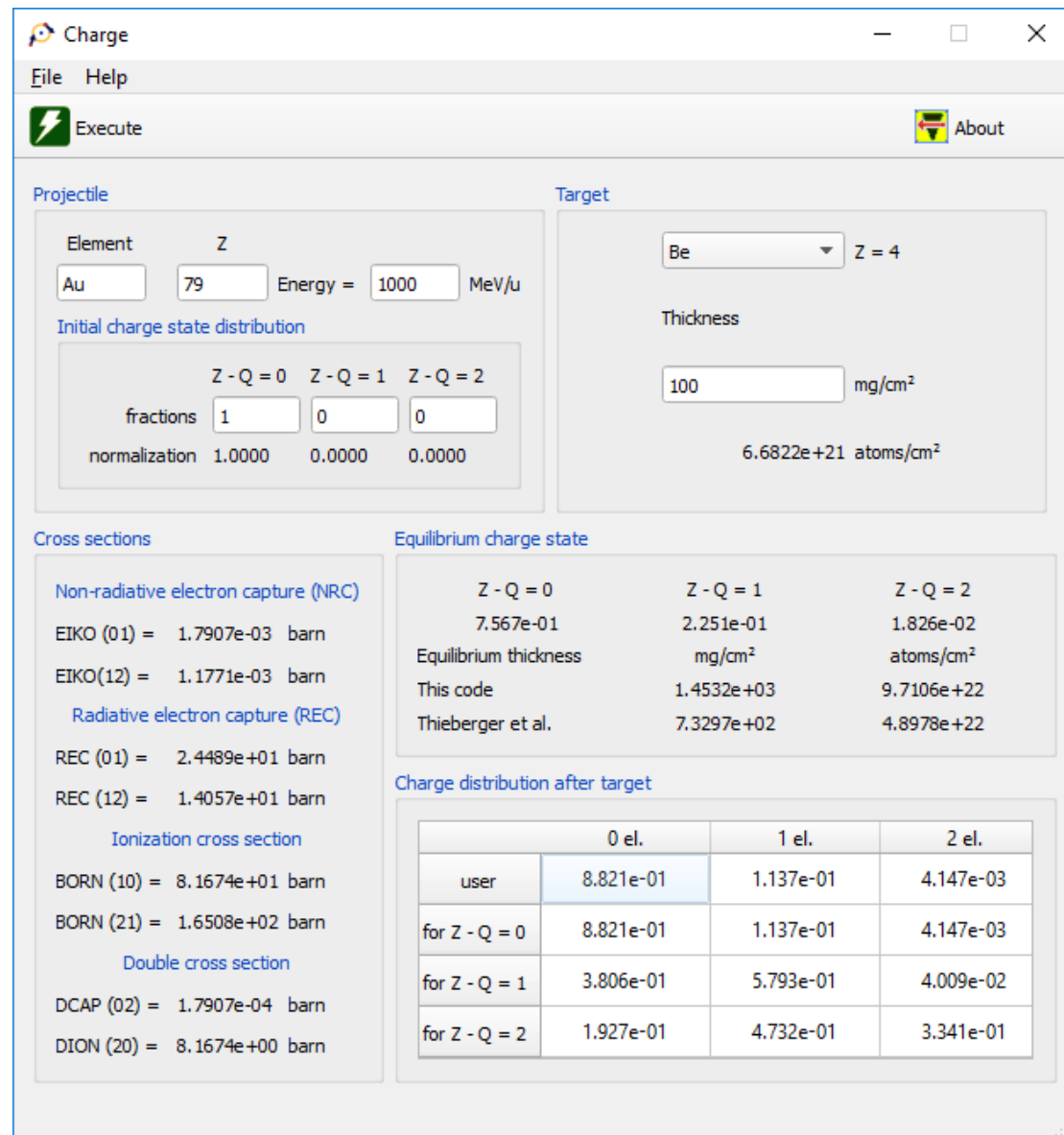
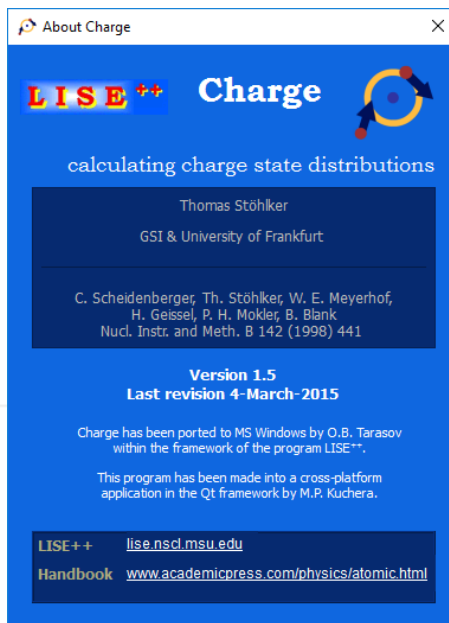
- Introduction
- Charge In Action
- Tutorials
- References

Introduction

The program Charge was transported to Qt from the Windows version within the LISE++ framework [1]. Charge calculates charge state distributions of relativistic heavy ions [2].

[1] <http://lise.nslc.msu.edu/lise.html>

[2] C. Scheidenberger, Th. Stöhler et al, Nucl. Instr. and Meth. B 142 (1998) 441





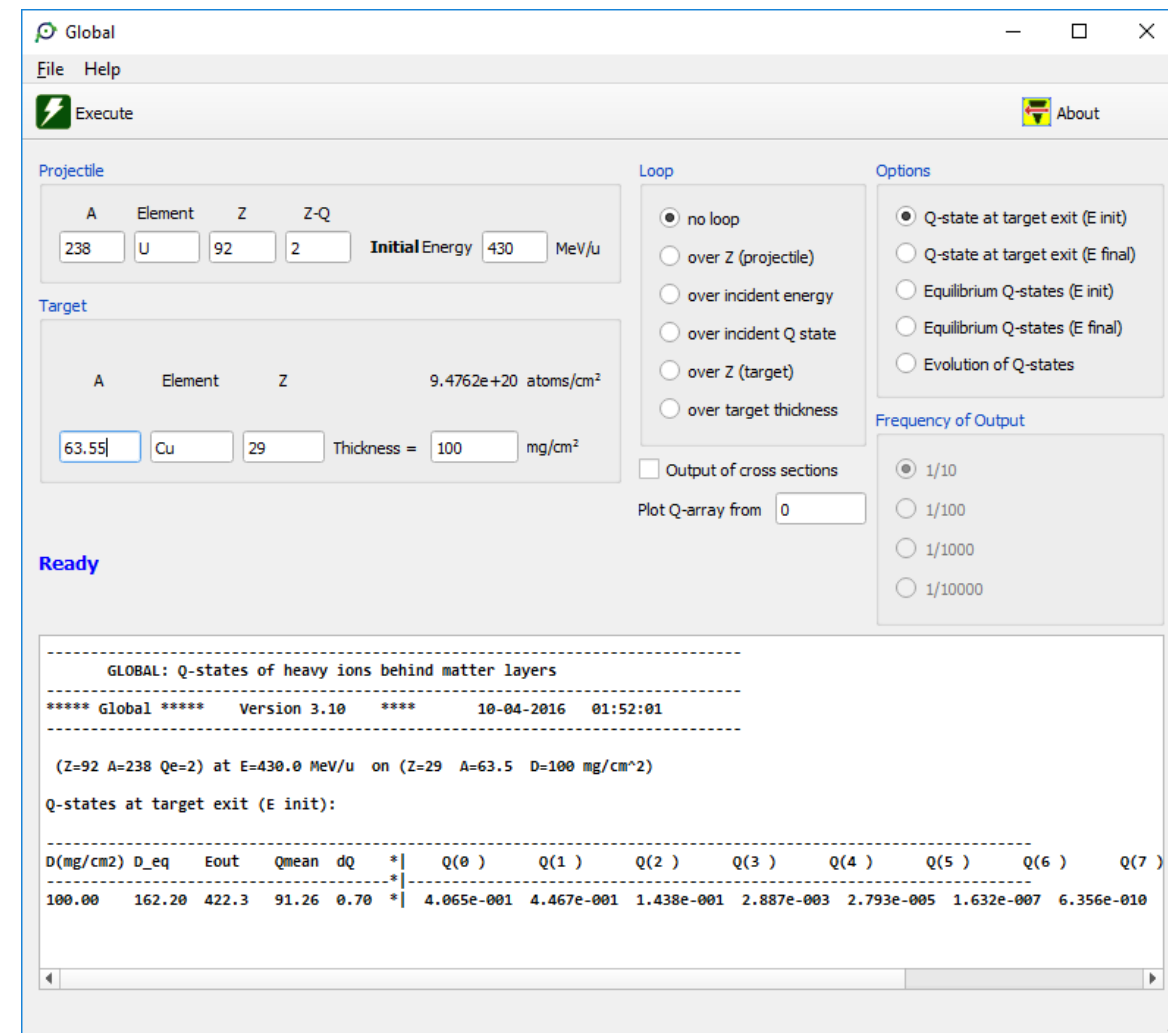
Documentation

- Introduction
- Global In Action
- Tutorials
- References

Introduction

The program Global was transported to Windows within the LISE++ framework [1]. Global calculates charge state distributions of relativistic heavy ions [2].

- [1] <http://lise.nslc.msu.edu/lise.html>
 [2] C. Scheidenberger, Th. Stöhlker et al, Nucl. Instr. and Meth. B 142 (1998) 441
http://web-docs.gsi.de/~weick/charge_states/



K Kantele Calculator

Documentation

- Introduction
- Kantele Calculator In Action
- Tutorials
- References

Introduction

The Kantele Calculator was transferred to Windows within the LISE++ framework [1]. The program is an implementation of the calculations in J. Kantele's *Nuclear Spectrometry Handbook* [2].

The Qt version of Kantele's Spectrometric Calculator operates the same way as the previous version packaged with LISE++. The interface has been redesigned to be more user friendly. The available calculations are on the left hand side of the window. A new tab populates the main frame with the chosen calculation. Only one tab per calculation type can be open at once.

[1] <http://lise.nsci.msu.edu/lise.html>

[2] J. Kantele, Academic Press Limited, 24-28 Oval Road, London NW1 7DX, Copyright 1995

Number	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 Barrier Heights for Heavy Ions
6	CaptuRat	yes	Capture Ratios in Electron-capture Decay
7	ChrdStat	yes	Average Equilibrium Charge-state of Swift Heavy Ions in Matter
8	Clebsch	yes	Clebsch-Gordan (Vector-Coupling) Coefficients
9	CompNucl	yes	Velocity, Kinetic and Excitation Energy of a Compound Nucleus
10	Compton	yes	Parameters in Compton Scattering
11	ConvertI	yes	Conversion of 10 Quantities to different Units
12	ConvertE	yes	Flexible Conversion of Units of Electron Energy and Momentum
13	CurveFit	yes	Fitting of Several Types of Curves
14	Doppler	yes	Doppler Shifts and Thermal Doppler Broadening

Atomic number, Z = 64

Mass number of nucleus, A = 156

Gamma-ray energy, E = 0.850 MeV

E	Half-life (sec)	M	Half-life (sec)
E1 =	3.78e-16	M1 =	3.10e-14
E2 =	2.51e-11	M2 =	2.43e-09
E3 =	2.54e-06	M3 =	2.45e-04
E4 =	3.86e-01	M4 =	3.73e+01
E5 =	8.27e+04	M5 =	7.99e+06

One Weisskopf-unit for the B(E2) = 4.99e-03 e2 b2

Global B(E2; up) prediction for 2+(1) = 4.83e-01 e2 b2

Global prediction for gamma T(1/2) of 2+(1) = 1.32e-12 sec



Units Converter

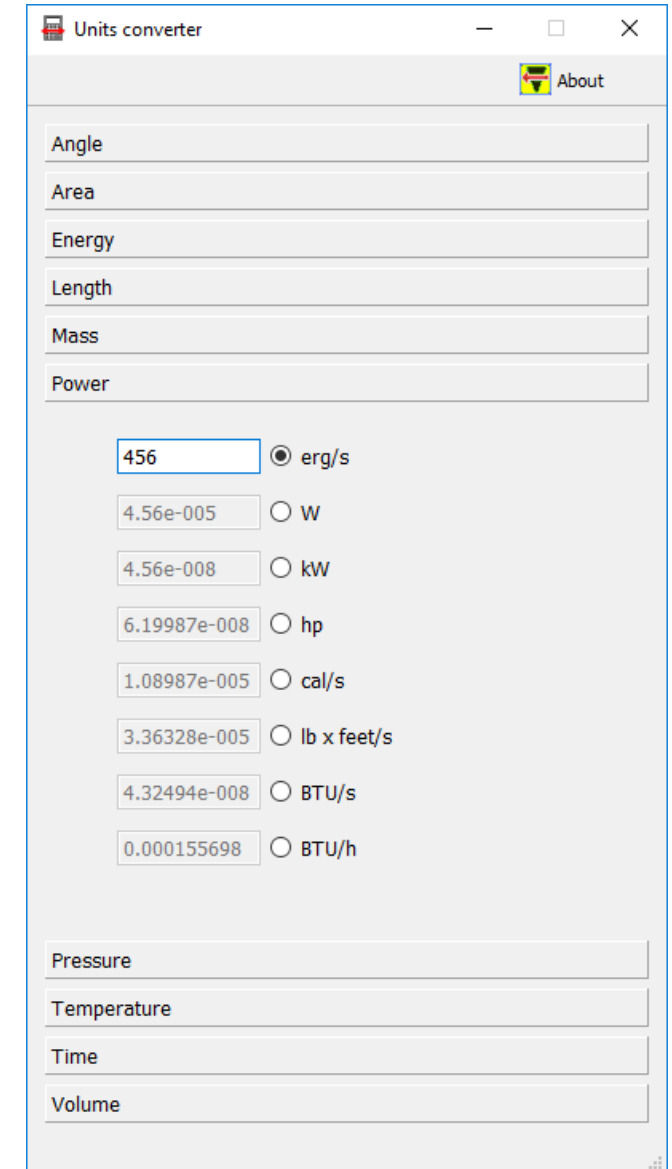
Documentation

- Introduction
- Units Converter In Action
- Tutorials
- References

Introduction

The Units Converter program was developed by O.B. Tarasov on the basis of the Handbook of nuclear spectrometry of J.Kantele within the LISE++ framework [1][2]. The program simply converts between various units.

- [1] <http://lise.nslc.msu.edu/lise.html>
 [2] Handbook of nuclear spectrometry, J.Kantele, Academic Press Limited, 24-28 Oval Road, London NW1 7DX, Copyright 1995



LISE++
☰

LISE++ Utilites Package

Version 1.0.5

The LISE++ Utilities Package contains five satellite programs implemented in the LISE++ framework. These programs have been ported from Borland to the Qt graphics framework. This is the first release in the LISE group's process of porting the entire LISE++ software suite to Qt.


Transportation from Borland to Qt is being done first and foremost to ensure longevity of the LISE++ program for future operating systems. Additional benefits include providing a 64-bit application, cross-platform compatibility, and the ability to take advantage of computational advances.


These programs were found under the "Utilities" tab in LISE++ and the new versions are now being distributed as a standalone package for the first stage of the transportation. For more information on each of these programs, explore the links below.


Programs in the Package


- [PACE4](#)
- [Charge](#)
- [Global](#)
- [Kantele Calculator](#)
- [Units Converter](#)


☰ LISE Qt Utilities ✕


PACE4


Charge


Global


K Spectrometric
Calculator


Units Converter

Version 1.0.4 2-July-2015

LISE++ Overview Utilities **Download** Team

Note: Please send any issues, comments, or suggestions to [kucheram at nscl](mailto:kucheram@nscl).

Download the LISE++ Utilites Package

Version 1.0.5

Please click on your operating system to choose installation:

Windows
Last updated: 3-September-2015

Mac
Last updated: 16-April-2015

Linux
Last updated: 12-June-2015

LISE Qt Utilities 1.0.5 Installation

Welcome to the LISE Qt Utilities Setup Wizard

This will install LISE Qt Utilities 1.0.5 on your computer.
It is recommended that you close all other applications before continuing.
Click Next to continue, or Cancel to exit Setup.

Publisher: NSCL / Michigan State University

Next > Cancel

Download Windows Version

64-bit LISE++ Utilities Package

32-bit LISE++ Utilities Package 64-bit compatible.

Installation Instructions
Double click .exe file, follow instructions on screen to Install.

Close

Download Linux Version

Debian LISE++ Utilities Package

Ubuntu LISE++ Utilities Package 64-bit application

Ubuntu LISE++ Utilities Package 32-bit application

Red Hat LISE++ Utilities Package Coming Soon!

Installation Instructions

```
tar xfv LISE_Utilityies_Linux.tar.gz to extract the package.
cd LISE_Utilityies_Linux/ to enter folder.
./run.sh to run the software.
```

The screenshot shows the LISE++ application window. On the left, there are configuration panels for Projectile ($^{40}\text{Ar}^{18+}$: 140 MeV/u 1pA), Fragment ($^{32}\text{S}^{16+}$), Target (Be 500 micron), and Stripper (n/a). Below these are detector and filter settings for D1, D2, D3, D4, FP_PPAC0, FP_PPAC1, FP_SLITS, FP_PIN, and FP_SCI.

The main area displays a periodic table with elements colored in red, blue, and grey. A context menu is open over the table, listing various distribution types:

- Block selection distributions
- Angular distributions
- Horizontal (X) space distributions
- Vertical (Y) space distributions
- Momentum distributions
- Energy distributions
- Total Kinetic Energy distributions
- Electrostatic rigidity distributions
- Beam and Setting fragment change state distributions
- Debug distributions
- Debug information
- Brho selection plot
- Wedge selection plot
- Isoteric Gamma strectrum
- Transmission characteristics
- Range distributions
- Charge distributions
- Average Ionic charrge distributions
- Cross Section distributions
- Systematic distributions (Q_g, Q_qq, dB_E, dB_Esn)
- Velocity after reaction
- Block selection distributions

At the bottom right, there are status indicators: Ncalc = 0, Sum = 0, and a checkbox for No charge states.

Production Mechanism

Reactions: Energy Loss, Straggling | Charge states | Databases: Masses, Isomers

40Ar(140.0 MeV/u) + Be -> 32S

0 - [> 15 AMeV] J.Winger et al., NIM B 70(1992)380; modified

Optimization of "charge state" transmission calculations (efficient if there are two or more "Material_Dispersive block" combinations)

Charge state suppression values

Calculate a charge state value for ALL points of enegy distribution

No (only for middle point) Yes Auto Calculate if Energy below 30 MeV/u

important for low energy

Coefficient for the Leon's charge state distribution

Width (dn) 1 (default 1) Correction factor (gzf) 1 (default 1) Zp power factor = 0.477 (default: Leon 0.477, Baron 0.447)

Calculation method of Equilibrium thickness for "Physical Calculator" 0 - "Charge": NIM B142(1998)441

Make default OK Cancel

Periodic Tables of Elements

PERIODIC TABLE OF ELEMENTS

Cancel

Target

Be Density 1.85 g/cm3 State Solid Dimension 1.85 mm Angle 1.85 degree

Thickness at 0 degrees 2540.5405 micron Effective Thickness 2540.5405 micron

Thickness at 40 degrees 470 microm2 Effective Thickness 470 microm2

Compound dictionary

OK Cancel

Prefragment and Evaporation calculations settings

Prefragment search options

Excitation energy 40.36 MeV

Method of prefragment search

Evaporation options

Dimension of evaporation distributions [32] 16

Version of Cross-Section evaporation file brief

Correction dR for the deduced effective Coulomb barrier for the TUNNELING mode [fm]

Fission Barrier Model = "ROR" - RLDIM(Cohen) Barfac = 1

State density [A] - Equidistant model [B] - as [A] + pairing corrections [C] as [B] + shell corrections

Dispersive effects in fission use Kramers's factor use Gamma_f(t) as a step function

Break-up parameters

OK Cancel Help

Beam

Element Ar q+ 18

Beam energy 140 MeV/u TKE 5593.35 MeV Brho 3.9206 Tm P 21.157 GeV/c U 3.11e+5 KV

Emittance

1. X mm 1 Gaussian 2. T mrad 6 Gaussian 3. Y mm 1 Gaussian 4. P mrad 8 Gaussian 5. L mm 0 Gaussian 6. D % 0.07 Gaussian

Beam intensity 18 enA 1 pA 6.25e+9 pps 0.0056 KW

1D - shape (Distribution method) 2D - shape (Monte Carlo method)

beam respect to spectro d X mm d T mrad d Y mm d P mrad d T degree d P degree

Energy Loss in the target box [kW] 0.000757 RF frequency 20 MHz Bunch length 1 ns

OK

Physical calculator

Table of Nuclides

Energy 12.0109 MeV/u Brho 1.0000 Tm Erho 47.7482 MJ/C P 4796.68 MeV/c p_trnsp 0.299792 GeV/c

Energy 11.9972 AMeV TKE 383.909 MeV Velocity 4.76832 cm/ns Beta 0.1590541 Gamma 1.012894

after/into Si 513 micron

Energy Remain 0 MeV/u Energy Loss 383.91 MeV Energy Strag. (sigma) 0.0088026 MeV/u Angular Strag. (sigma) 10.715 mrad(plane) Lateral spread (sigma) 0.17033 microns Brho (for Q=Z) 0 Tm

Equilibrium values for material "Si"

Charge State <Q> 15.57 dQ (sigma) 0.55 Thickness 0.26049 mg/cm2

Range and Energy Loss to Si

Range 36.9128 mg/cm2 dRange (sigma) 0.089352 mg/cm2

Energy Remain 0.000 MeV/u Material thickness 36.913 mg/cm2 for energy rest 159.02 micron

Calculation method of Energy Losses 2 Energy straggling 1 Charge States 3 Angular straggling 1

Print Help Quit

Kinematic calculator (relativistic)

Reactions

Participants

A	Beam	40Ar	-35.04	0	Beam energy = 140.0 MeV/u
B	Target	9Be	11.35	0	Intensity = 1 pA
C	Fragment	40Ar	-35.04	0	Target thickness = 1e-1 micron
D	Residual	9Be	11.35	0	Q-value = 0.00 MeV

Reaction takes place at the ENTRANCE of the target MIDDLE of the target EXIT of the target

Setup

Search an angle in CM from 0 degrees and up from 180 degrees and down

Angle (deg) = 100 100 50 130

Calculations

	LAB	CM	
Conting in monitor	1.13e-2	1.13e-2	pps
Differential Cross Section	7.29	0.33	0.203 0.203 mb/sr
Energy after reaction	124.55	68.508	4.8642 91.407 MeV/u**
Energy at the entrance of the target	124.55	68.508	MeV for gamma [MeV]
Maximum Angle	13.03	90.00	deg
Solid Angle	0.2	0.2	7.17 0.325 msr
delta Theta	0.57	0.57	3.9 1.1 deg

Kinematics plots Rutherford plot 2D fragment plot (Monte Carlo) 3-body kinematics

Quit Help

Fusion -> Residues

Evaporation settings 40Ar(140.0 MeV/u) + 9Be -> 49Tt* (Ex=1054.7 MeV) Fission barrier

Fusion properties

Transmission probability for a one-dimensional potential barrier Classical Quantum-mechanical

h_omega - Curvature parameter of the parabolic potential describing the barrier (default value 3 MeV) 5 MeV

Probability for compound nucleus formation P_CN

Take into account the Probability for compound nucleus formation P_CN according to V.Zagrebaev & W.Greiner, PRC78, 034610 (2008)

Fission barrier vanishing

Take into account the Fission barrier vanishing with 0 - "Barfit" - A.J.Sierk, PPRC33(1986)2039 1 - "FisRot" - S.Cohen et al., An.P 82(1974)

Nuclear potential

Bass formalism Wood-Saxon

V0 = 105 MeV R0 = 1.12 fm a = 0.75 fm

Fusion L-diffuseness 1 MeV

Calculation

L (Bfis=0) = 40 L critical = 40 L direct(@CpCt) = 107 L (Bfis=0) = 40 L critical = 40

Partial Cross Sections Barrier properties as f(L) Potentials Vi = f(R) Bass Fusion CS & Barrier T,PCN,dEx-chan as f(L) 2D: Barrier V=f(R,L) & dVdR

Partner site

General reaction characteristics Fusion information window Fusion Evaporation

OK Cancel Help

215 dialogs in v. 9.8

~225 in v.9.10.280

~90% have been ported (April 2016)

LISE++ hierarchy

	A	B	C
1	1st level	2nd level	3rd level
2			
3	Options	preferences	cross_section
17	Experiment Settings	Beam (Projectile)	
95	Optics	Manual recalc_e-blocks (F)	
96		Upload linked COSY matrices (F)	
97		Envelop_plot (ch_nucleus)	
98		First_matrix	
99			
100		Optic settings (fast editing)	P
101			
102			Selected Block Edit
103			Cuts+angular acceptance
104			Optical matrix
105			First_matrix
106		Brho	P
107		Ideal_magnet	View
108		Optic_fit (optimization)	Beam(Projectile)
109			F
110			Levmar_min_settings
111		Gamma_detect	First_matrix
112		Setting Fragment	
113			P
114			
115	Physics Models	product_mechanism	
201	Calculation	Goodies	range_to
232	Utilities	range_optimizer	
233		Radioactivity_decay/d_proton_rad	
234		Radioactivity_decay/d_alpha_dec	
235		Radioactivity_decay/d_cluster_radioactivity	
236		Radioactivity_decay/d_spont_fission	
237		Radioactivity_decay/d_decay_analysis	
238		Reaction_utilities/d_reaction_characteristics	ar40
239			be9
240			ti49
241		Reaction_utilities/d_diff_converter	fragment
242			target
243			beam
244		Reactions_utilities/d_init_sett_evap_calc	
245		Reactions_utilities/d_cs_analysis_abr_abl_model	d_choose_plot_type
246		Plots/d_range_energy_loss_plots	
247		Plots/d_angular_stragglng_plot	

This fall

1. GEMINI⁺⁺ GUI v.2

- a) Finish the code construction (5% left)
- b) Finish documentation (30% left)
- c) Communicate to R.Charity to get an agreement
- d) Release (announcement)

2. LISE⁺⁺ Qt porting

- a) Finish construction of dialogs (~10%)
- b) Dynamical menus
- c) Dynamical lists

3. *ETACHA Qt (??)*

PHYSICAL REVIEW C 82, 014610 (2010)

Systematic description of evaporation spectra for light and heavy compound nuclei

R. J. Charity

Department of Chemistry, Washington University, St. Louis, Missouri 63130, USA

(Received 7 May 2010; published 14 July 2010)

To systematically describe evaporation spectra for light and heavy compound nuclei over a large range of excitation energies, it was necessary to consider three ingredients in the statistical model. First, transmission coefficients or barrier penetration factors for charged-particle emission are typically taken from global fits to elastic-scattering data. However, such transmission coefficients do not reproduce the barrier region of evaporation spectra and reproduction of the data requires a distributions of Coulomb barriers. This is possibly associated with large fluctuations in the compound-nucleus shape or density profile. Second, for heavy nuclei, an excitation-energy dependent level-density parameter is required to describe the slope of the exponential tails of these spectra. The level-density parameter was reduced at larger temperatures, consistent with the expected fadeout of long-range correlation, but the strong A dependence of this effect is unexpected. Last, to describe the angular-momentum dependence of the level density in light nuclei at large spins, the macroscopic rotational energy of the nucleus has to be reduced from the values predicted with the finite-range liquid-drop model.

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PACS number(s): 21.10.Ma, 24.60.Dr, 25.70.Jj

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GEMINI: A Code to Simulate the Decay of a Compound Nucleus by a Series of Binary Decays

[Click here to enter subtitle (optional)]

Prepared by

R. J. Charity

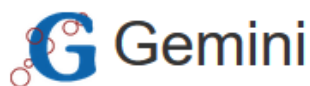
Abstract

The details of the statistical-model code GEMINI are discussed. It is shown that GEMINI does a reasonable job at reproducing experimental charge distributions for light compound nuclei. However for heavier systems, it overpredicts the width of the fission mass distribution. A new code GEMINI++ has been written to address this problem.

1. Advanced: modern & well-known
2. Open C++ source, well written and documented
3. Conversation with Robert to create a shell
4. To benchmark statistical-models codes (PACE4, GEMINI++, LISE LisFus)
5. Use the GEMINI event generator in LISE++
6. Important for future reaction mechanism model (ADA, AF2 and ..) development in LISE++

95% done

<http://lise.nscf.msu.edu/porting/gemini.html>



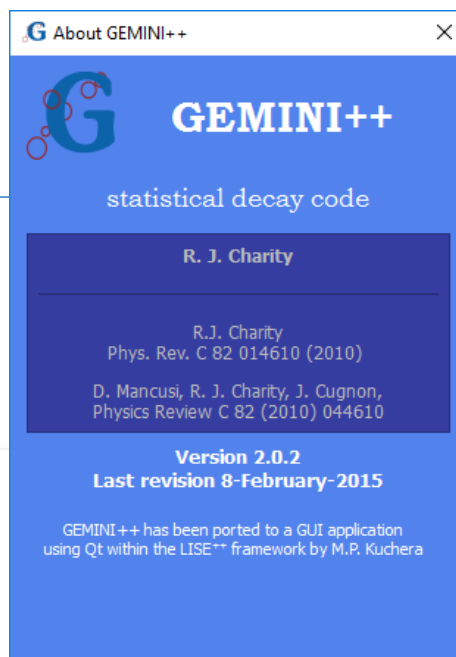
Documentation

- Purpose
- Implementation
- In Action
- Download

Introduction

A Gemini++ Graphical User Interface (GUI) utility was created to complement with the other utilities in the LISE++ Utilities Package. The LISE++ Utilities Package is currently a package of 5 satellite utilities that are either used in the LISE++ projectile fragmentation software, or of use to the users of LISE++. The Gemini++ libraries provide useful calculations for LISE++ users. Specifically, users can quickly compare yields and other interesting results with other codes provided in the Utilities, such as PACE4. This is great for those users who are not familiar with command-line programs, using libraries or just want to quickly check calculations.

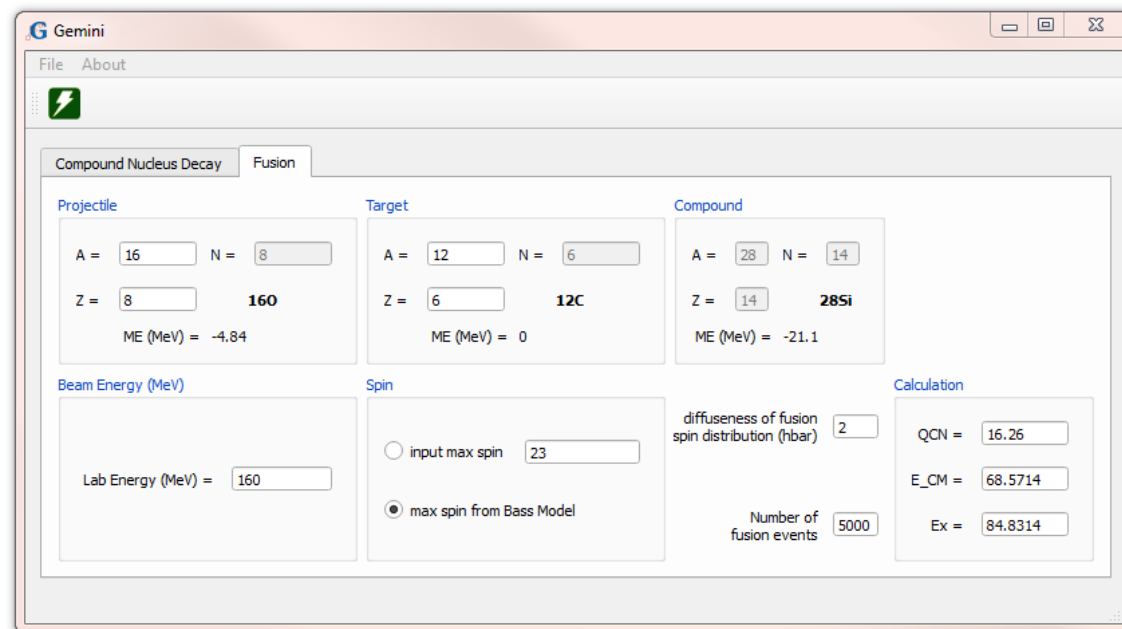
- [1] R.J. Charity, Phys.Rev.C 82, 014610 (2010)
- [2] D. Mancusi, R.J. Charity, J. Cugnon, Phys.Rev.C 82, 044610 (2010)
- [3] R.Charity: GEMINI: A Code to Simulate the Decay of a Compound Nucleus by a Series of Binary Decays. pdf.



Implementation

The Gemini++ code was implemented in the Qt graphics framework. Qt is a C++ graphics framework for cross-platform development. This can be compiled into Windows, Mac, and Linux GUI executables. The executables would be distributed for installation with our LISE++ Utilities Package. The mass tables were updated to use the AME2012 database where appropriate. Specifically, where the original code checked for an experimental value, the AME2012 database is checked instead. The AME database is implemented as a SQLite database for this project. In order to facilitate a cross-platform implementation, the *.tbl and *.tl files are stored as Qt "resources". This requires some syntax changes in the code. For this reason, the code was verified against the command-line version of the code. The random-number generator was fixed to constant values for both programs and results were compared.

The simple example codes of testFusion and testDecay were used as reference for the Gemini Utility. Results from these are easily compared to PACE, another utility program, by looking at residual yields of nuclei. See below for a look at the GUI input and results forms.



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)

Spectrometric Calculator by J.Kantele

The code "CHARGE"

The code "GLOBAL"

Units Converter

BI (search of 2-dimensional peaks)

Converter of FORTRAN-files to C-files

PACE4 (fusion-evaporation code)

PACE4 & GEMINI calculations plot

MOTER (ray tracing code)

MOTER's calculations plot

v.9.10.257 from 01/07/16

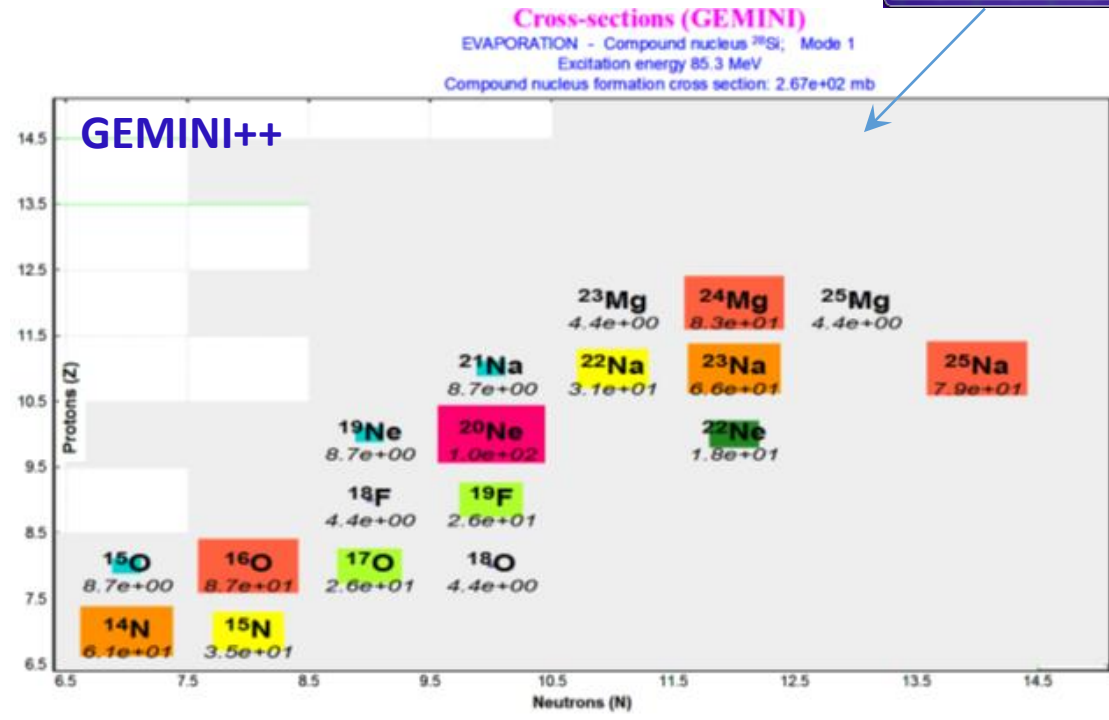
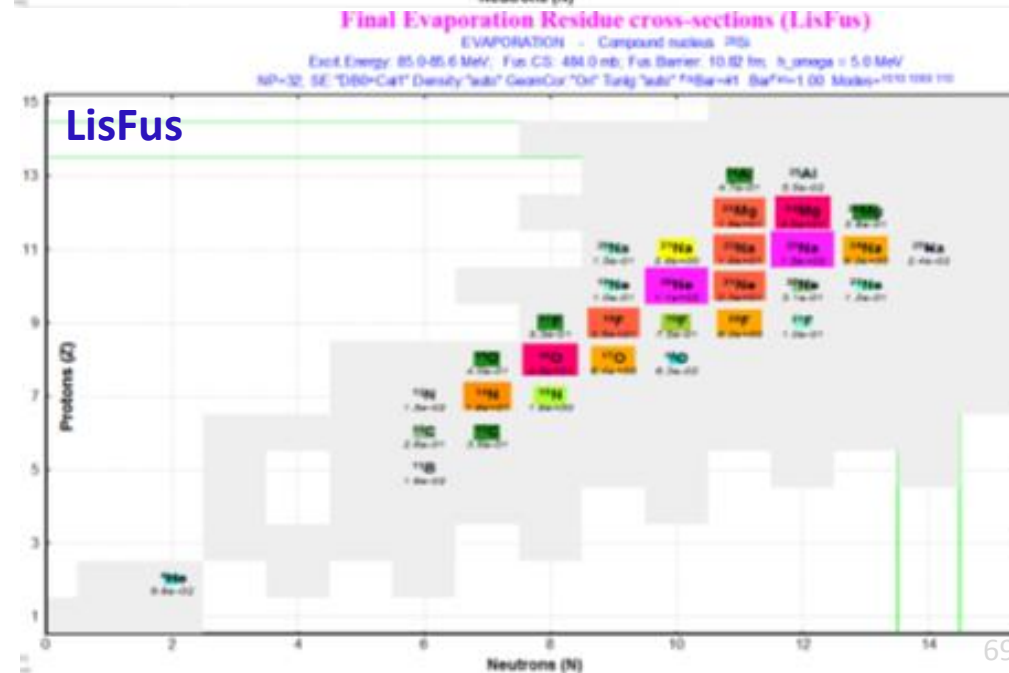
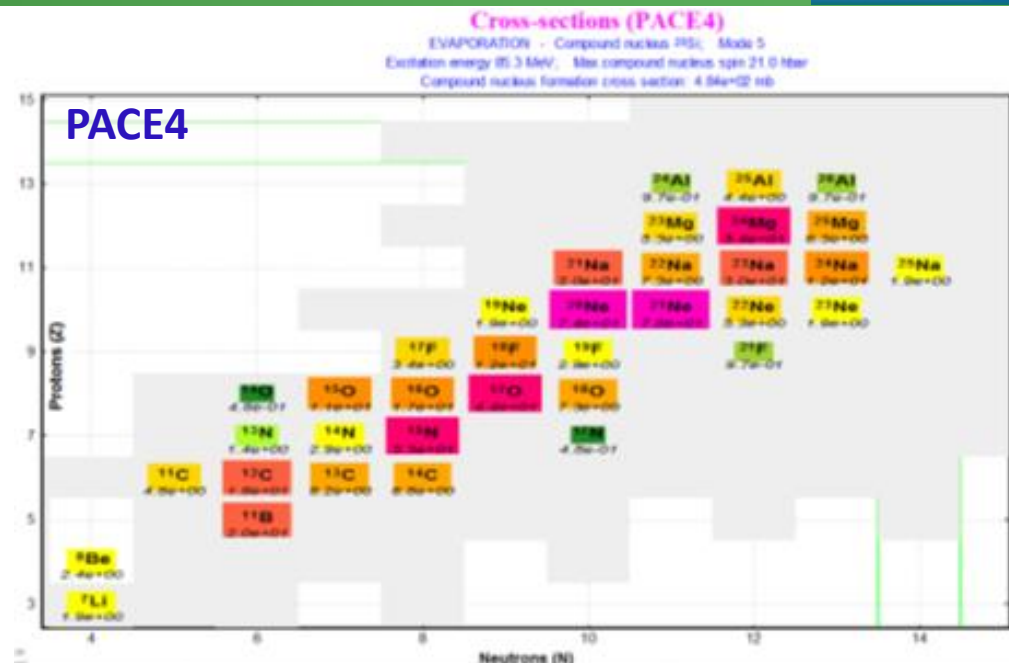
Open

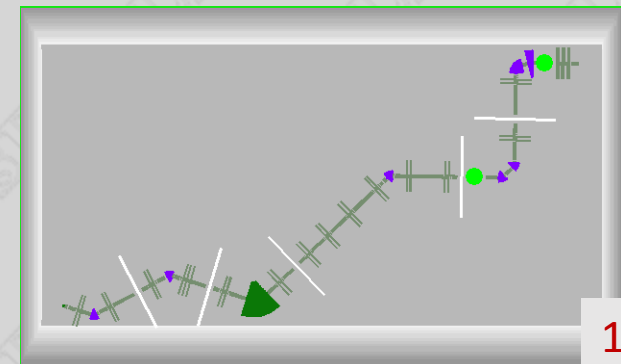
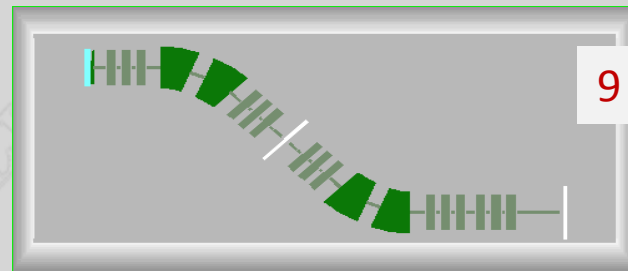
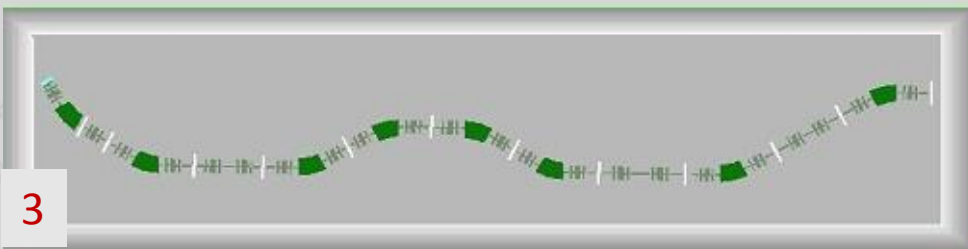
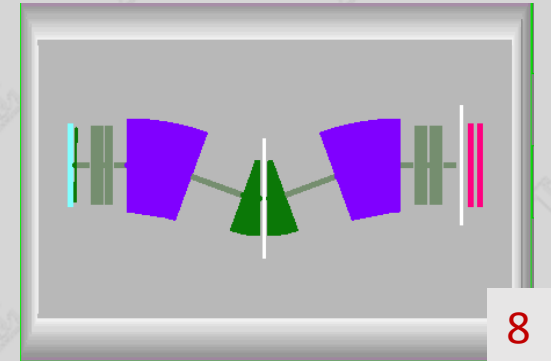
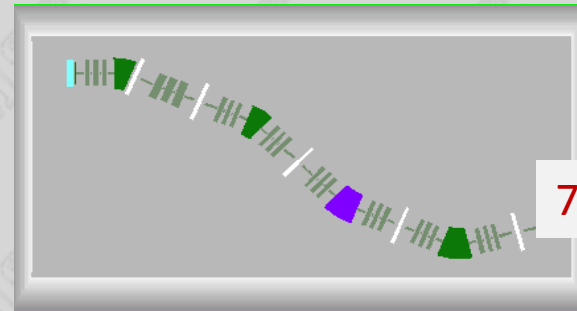
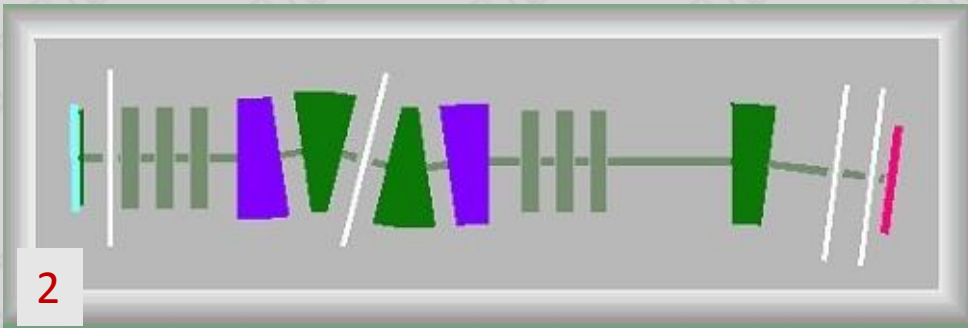
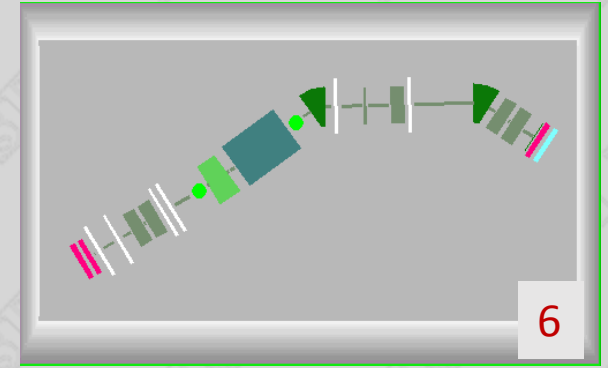
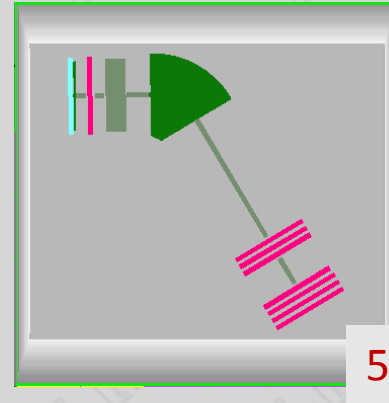
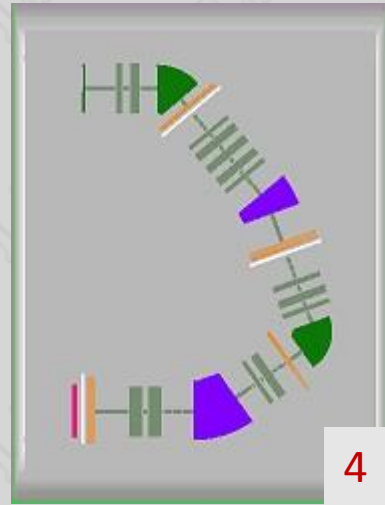
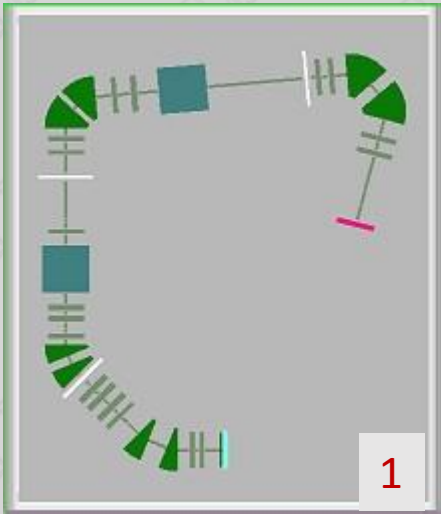
Look in: LISE_development

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Reverse	11/13/2015 3:50 PM	Fi
Rutherford	12/4/2015 5:54 PM	Fi
28si.cs4	1/7/2016 12:52 PM	C:
gemini_test.cs4	1/7/2016 12:39 PM	C:

File name: gemini_test.cs4

Files of type: PACE4 & GEMINI cross section files (*.cs4)





Discussions & Requests:

Fusion update:

Reverse configurations:

Optics minimization:

FRIB mass tables:

Scattering:

Radiation Residue Calculator:

Range optimizer (Gas cell utility) update:

Ionization energy database & Ion mass calculator:

Discussion of configurations in LISE⁺⁺:

ETACHA4:

Second order optics calculations of electric dipole:

S3:

LISE3:

SHELS :

SECAR :

FMA:

DRAGON:

EMMA:

HRS:

D.J.Morrissey, M.Hausmann, M.Portilio, H.Weick

D.J.Morrissey, M.Thoennessenn, Z.Kohley, G.Knyazheva

M.Bowry, A.Gade, M.Portilio, M.Hausmann

M.Hausmann, M.Portilio, D.Weisshaar

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M.Hausmann, H.Weick

D.J.Morrissey

Dominique Vernhet

Robert Hipple

Bertrand Jacqout, Omar Kamalou

Omar Kamalou

Andrey Popeko

H.Schatz, G.Berg, M.Couder

Darek Seweryniak

Chris Ruiz, D.A.Hutcheon, Ulrike

Matt Williams

Th.Baumann

Next for 2016:

- Version 10 release
- ETACHA4 (GUI)
- GEMINI++ (GUI)
- Porting, porting, and again porting....

Acknowledgements for discussions and support to

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