

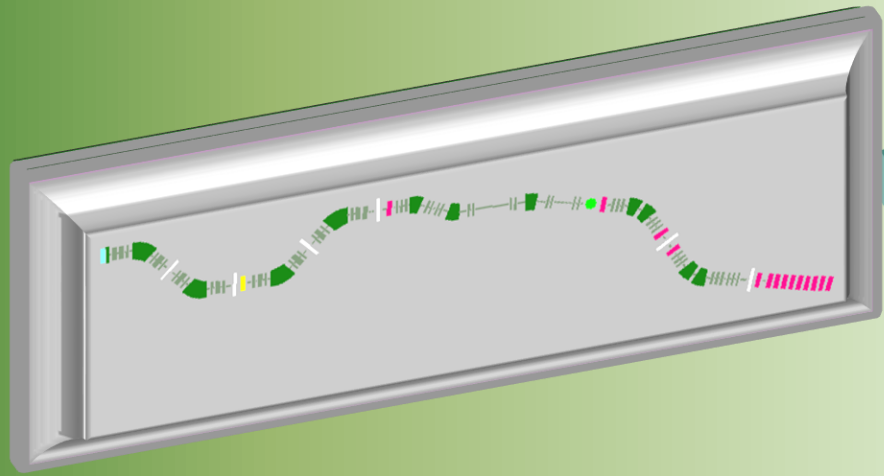
Oleg B. Tarasov
NCSL / MSU

October 2021

**Development of the LISE⁺⁺ code
to simulate rare isotopes production**


*Fall Meeting of the APS Division of Nuclear Physics
Fall Meeting of the APS Division of Nuclear Physics*

LISE⁺⁺



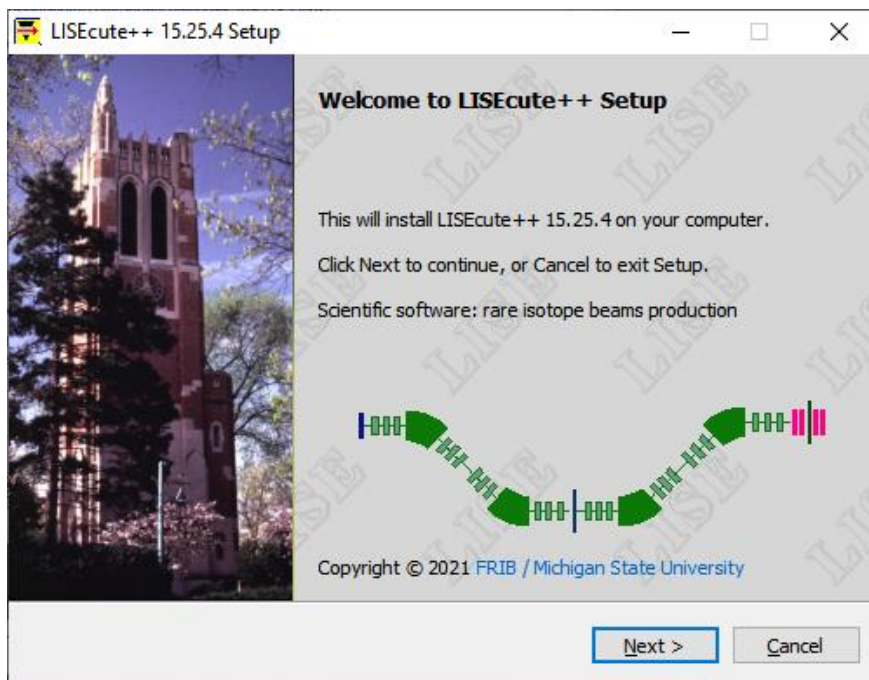
LISE⁺⁺

NSCL

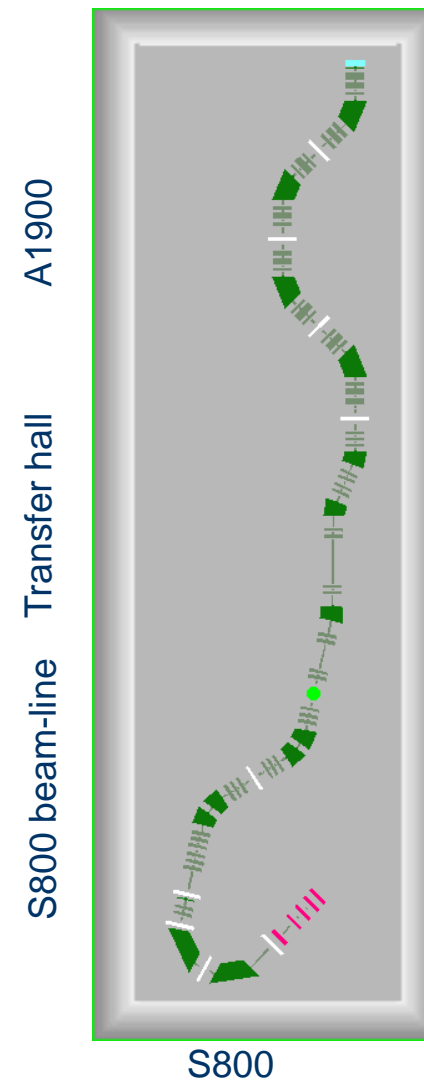
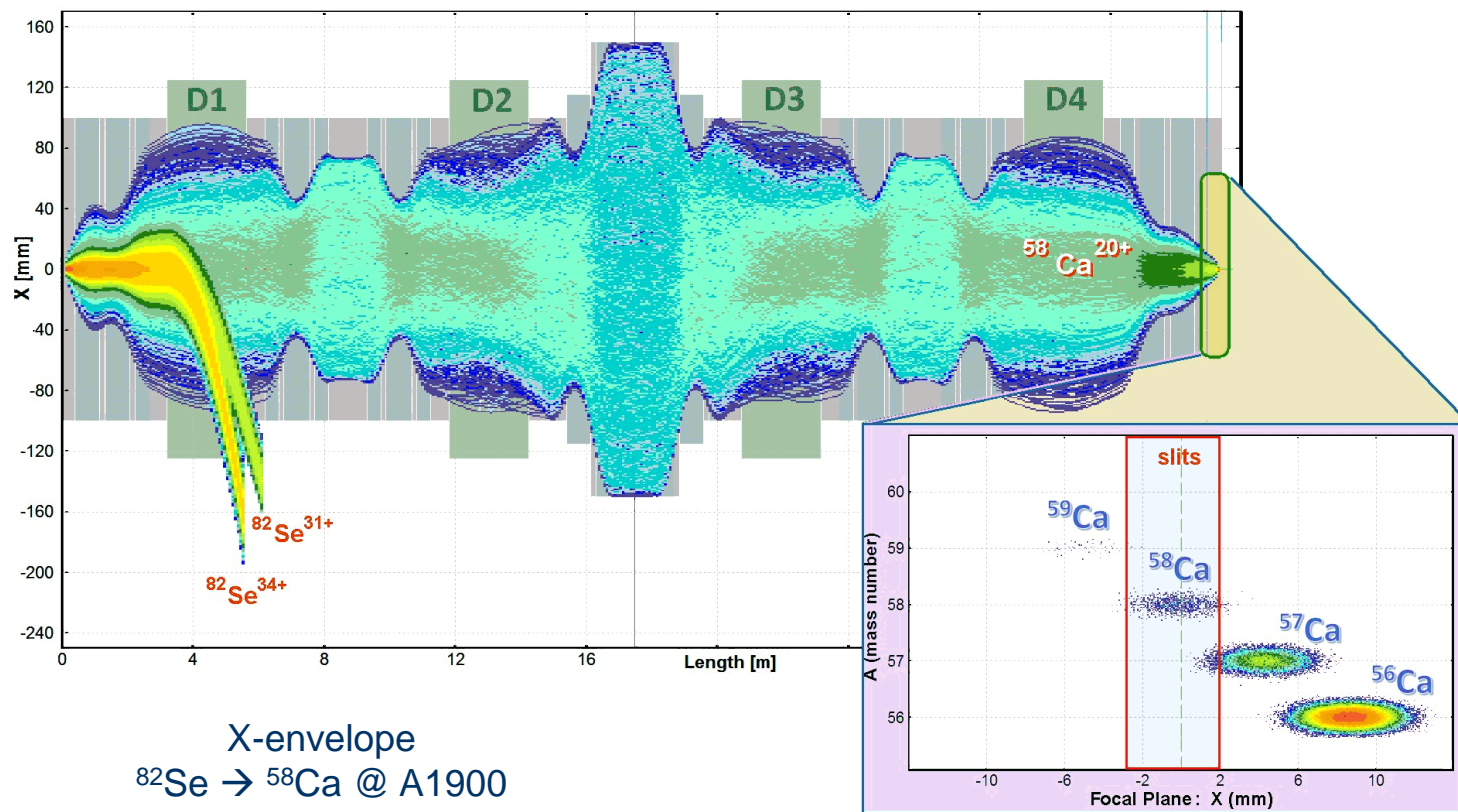


1. Rare Isotope Beam Production with Fragment Separators
2. LISE package transportation
3. New features
4. New code implementation
5. Reaction mechanism models development updates
6. The LISE⁺⁺ transportation team

- The program LISE⁺⁺ is designed to predict the intensity and purity of rare isotope beams (RIB) produced by In-flight separators
- The program is constantly expanding and evolving from the feedback of its users around the world
- Many “satellite” tools have been incorporated into the LISE⁺⁺ framework
- It can be freely downloaded from the following internet addresses:
<http://lise.nsl.msui.edu>



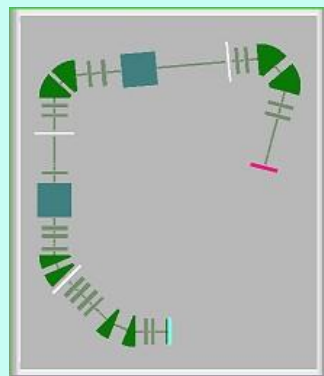
- predict the fragment separator settings necessary to obtain a specific RIB
- predict the intensity and purity of the chosen RIB
- simulate identification plots for on-line comparison
- provide a highly user-friendly graphical environment



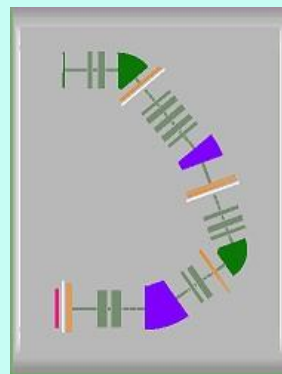
- Not only using classical reaction mechanism models, but actively developing fast and accurate in-house models of rare isotope production
- Includes secondary reactions in target
- Includes fragment production in materials (wedges, detectors)

O.B.Tarasov	Analysis of momentum distributions of projectile fragmentation products	NPA 734 (2004) 536-540
O.B.Tarasov, D.Bazin	Development of the program LISE: application to fusion–evaporation	NIM B204 (2003) 174-178
O.B.Tarasov, A.C.C.Villari	Fusion–fission is a new reaction mechanism to produce exotic radioactive beams	NIM B 266 (2008) 4670-4673
O.B.Tarasov	LISE ⁺⁺ development: application to low-energy fission of projectiles at relativistic energies	ENAM2004: EPJ A25 (2005) 751
O.B.Tarasov	LISE ⁺⁺ development: Abrasion-Fission	Preprint NSCL MSU, MSUCL-1300, 09.2005

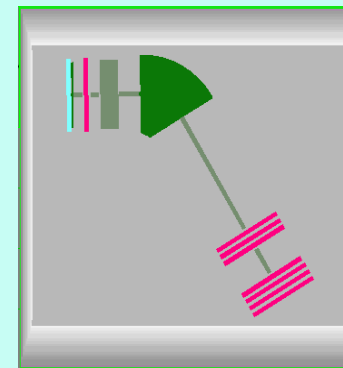
The LISE++ code may be applied at low, medium, and high-energy facilities (fragment- and recoil-separators with electrostatic and/or magnetic selections)



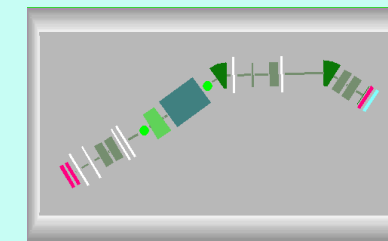
SECAR, MSU



DRAGON, Canada

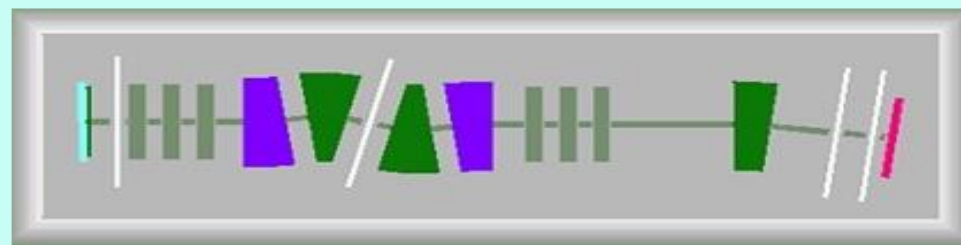


PRISMA, Italy

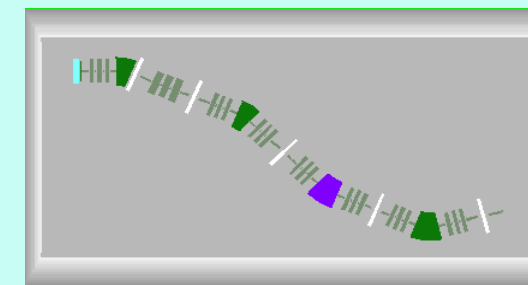


MARS, TAMU, USA

The LISE++ package includes configuration files for most of the existing fragment and recoil separators



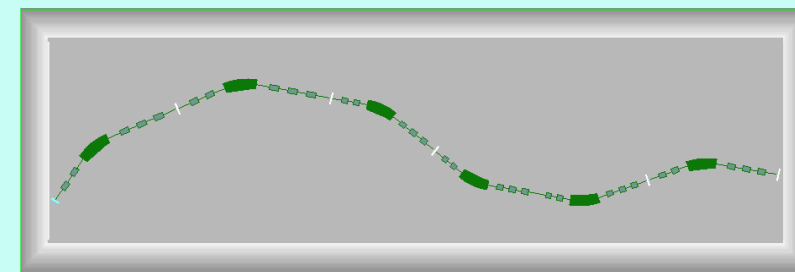
SHELS, Russia



S³, France

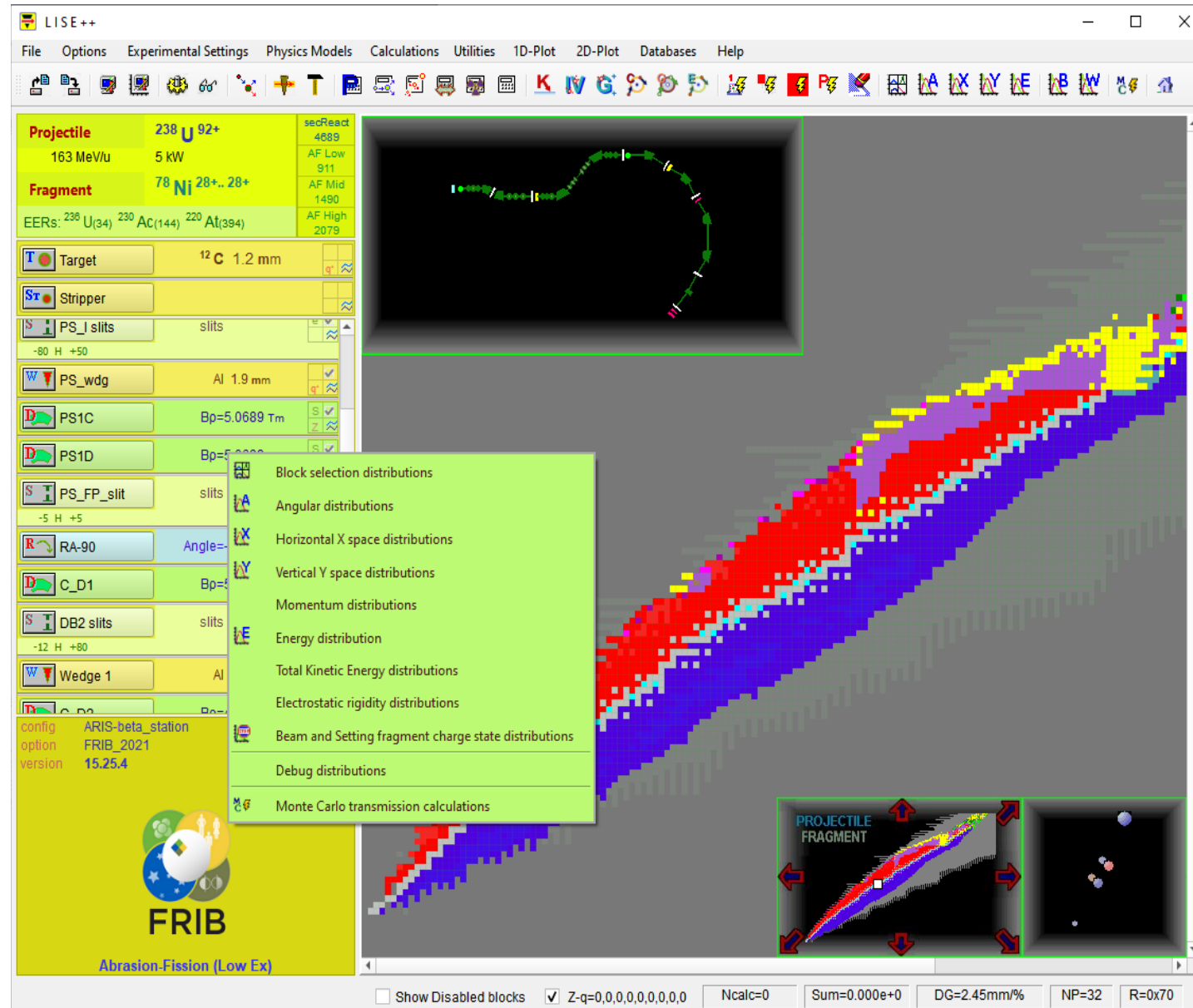


BigRIPS+ZeroDegree, Japan



SuperFRS_HEB, Germany

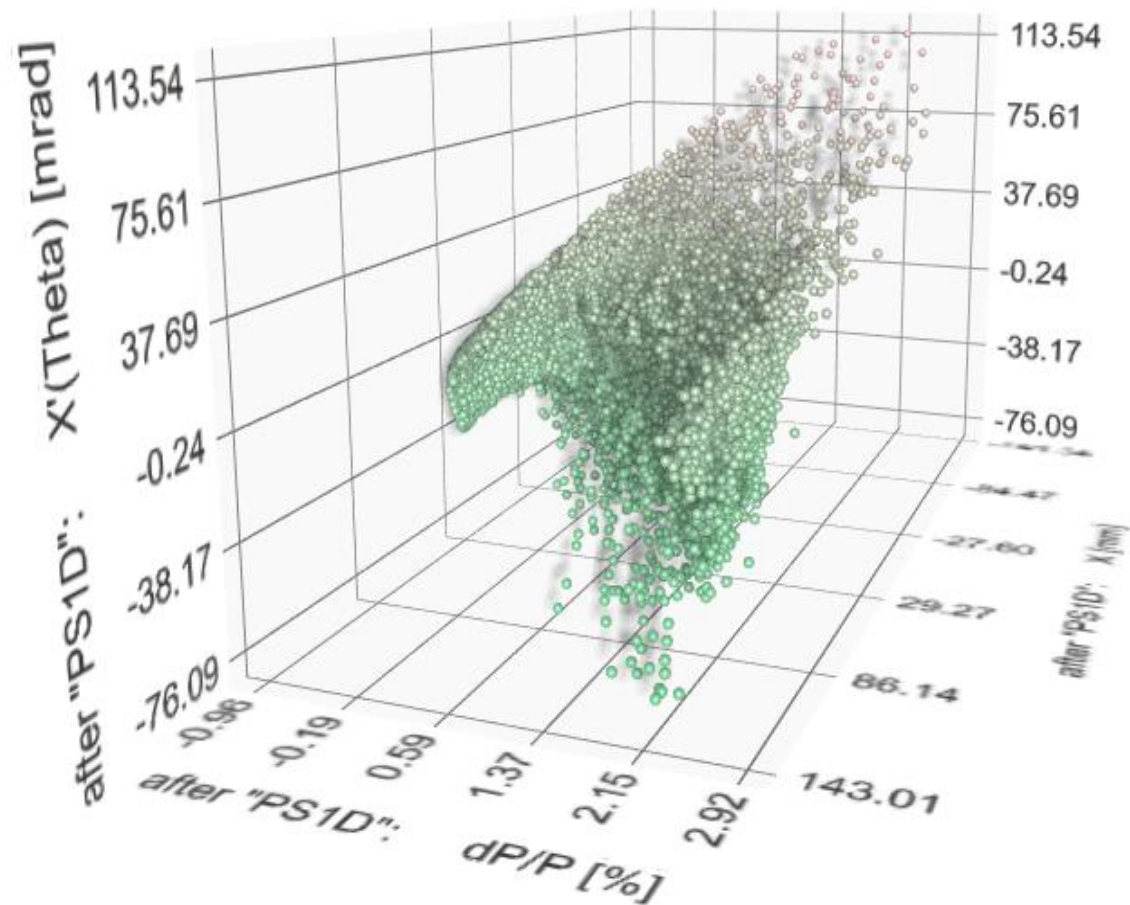
- The LISE⁺⁺ code (v.6-13) was developing at Borland C++ 5.02 IDE (integrating development environment), which is not compatible with the next Borland (Builder, Embarcadero C++) generations
- The LISE⁺⁺ software suite was recently ported to Qt-framework in order to
 - Aid in sustainability of the code
 - Support modern compilers and computing methods:
 - ✓ 64-bit operation
 - ✓ cross-platform compatibility (Windows, Mac, and Linux versions)
 - ✓ the ability to take advantage of computational progress (for example parallel computing methods)
 - ✓ integration with control systems



LISE⁺⁺ version 15, created using the Qt framework, is named **LISE_{cute}** to indicate a new generation different from the previous Borland-based versions.

X-X'-dP/P
in ARIS preseparator
focal plane

53Ar : Monte Carlo Transmission Plot

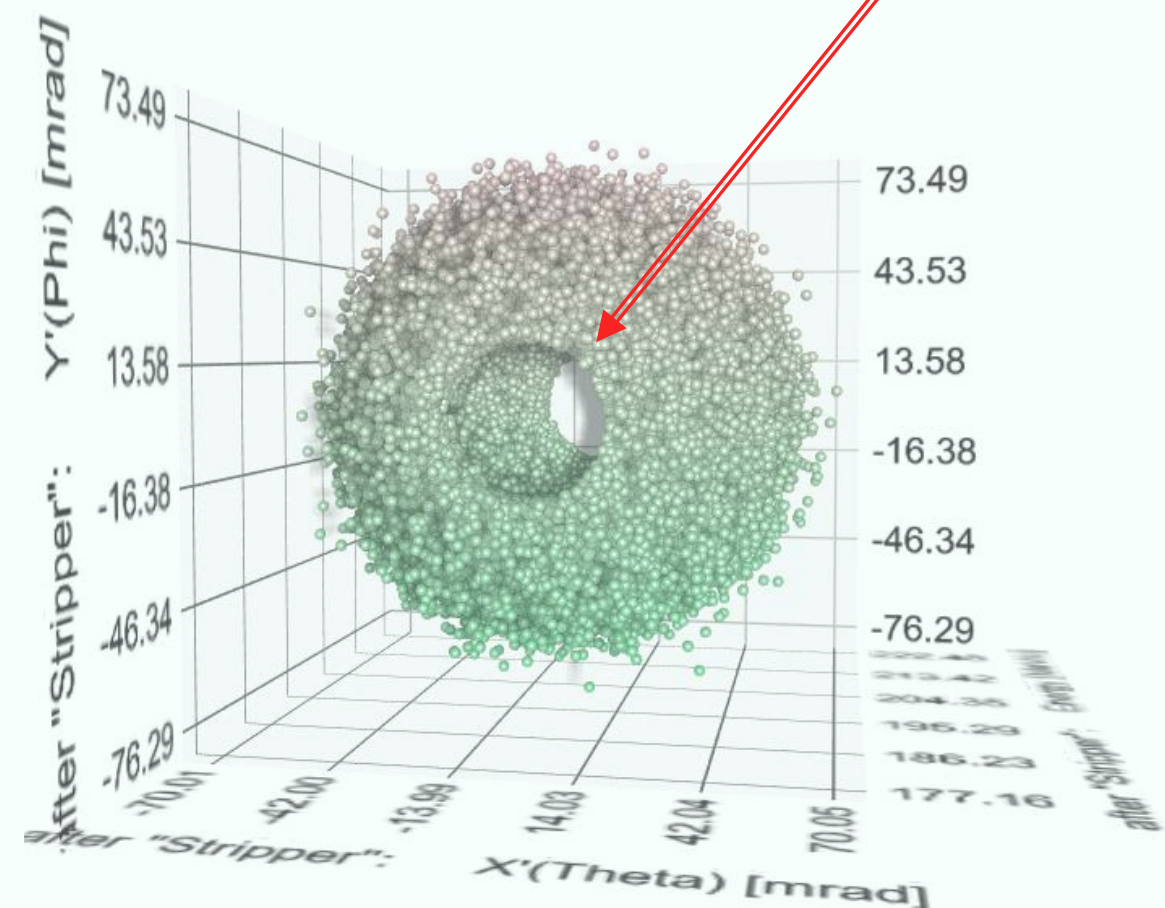


Projectile 238 U 92+
200 MeV/u 1 pA
Fragment 132 Sn 50+.. 50+
EERs: 237 U(34) 232 Th(108) 222 Rn(394)
Target 12 C 0.01 g/cm²

X'-Y'-E
after target
using the angle gate

132Sn : Monte Carlo Transmission Plot

Fission products in 3-D



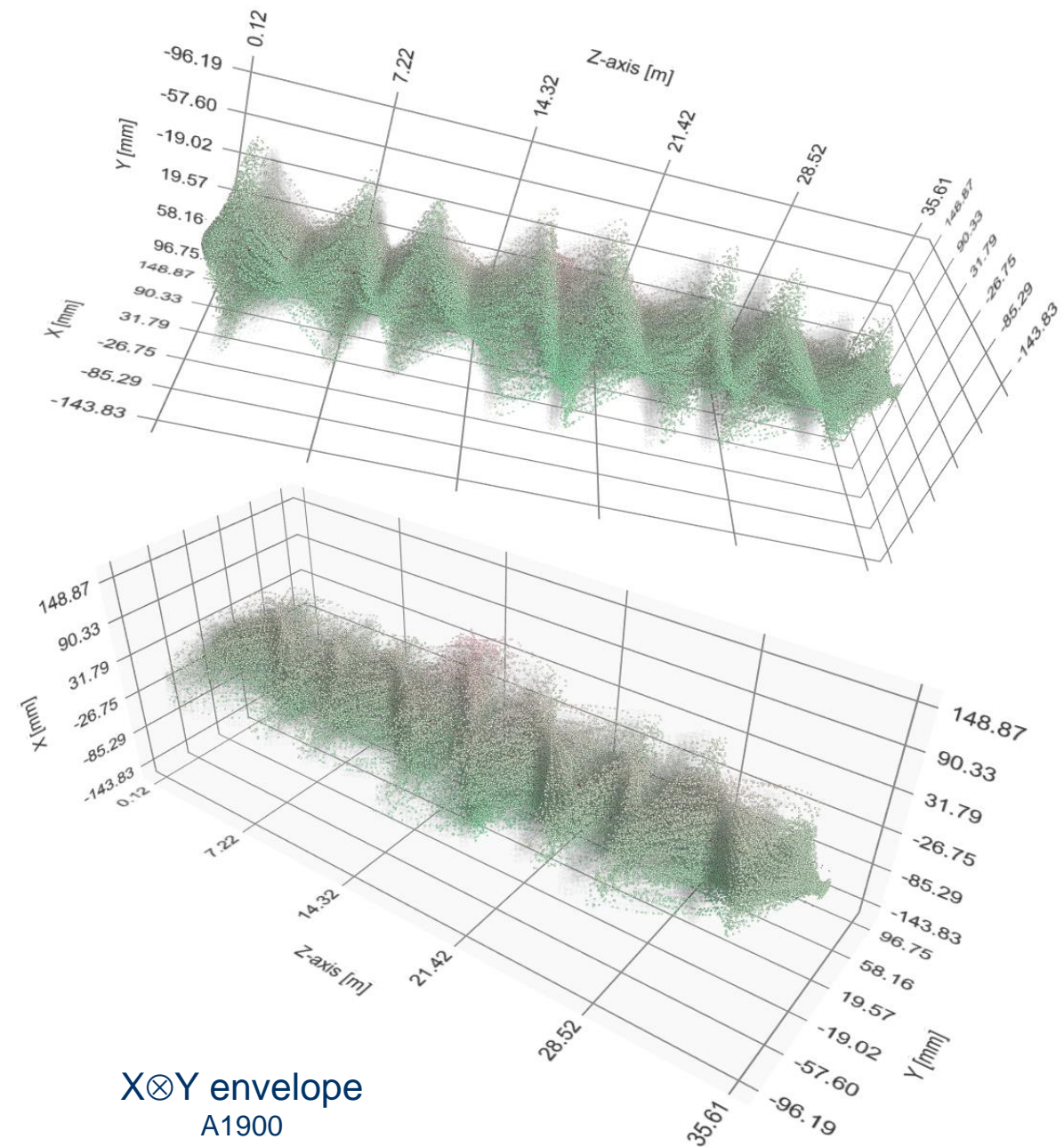
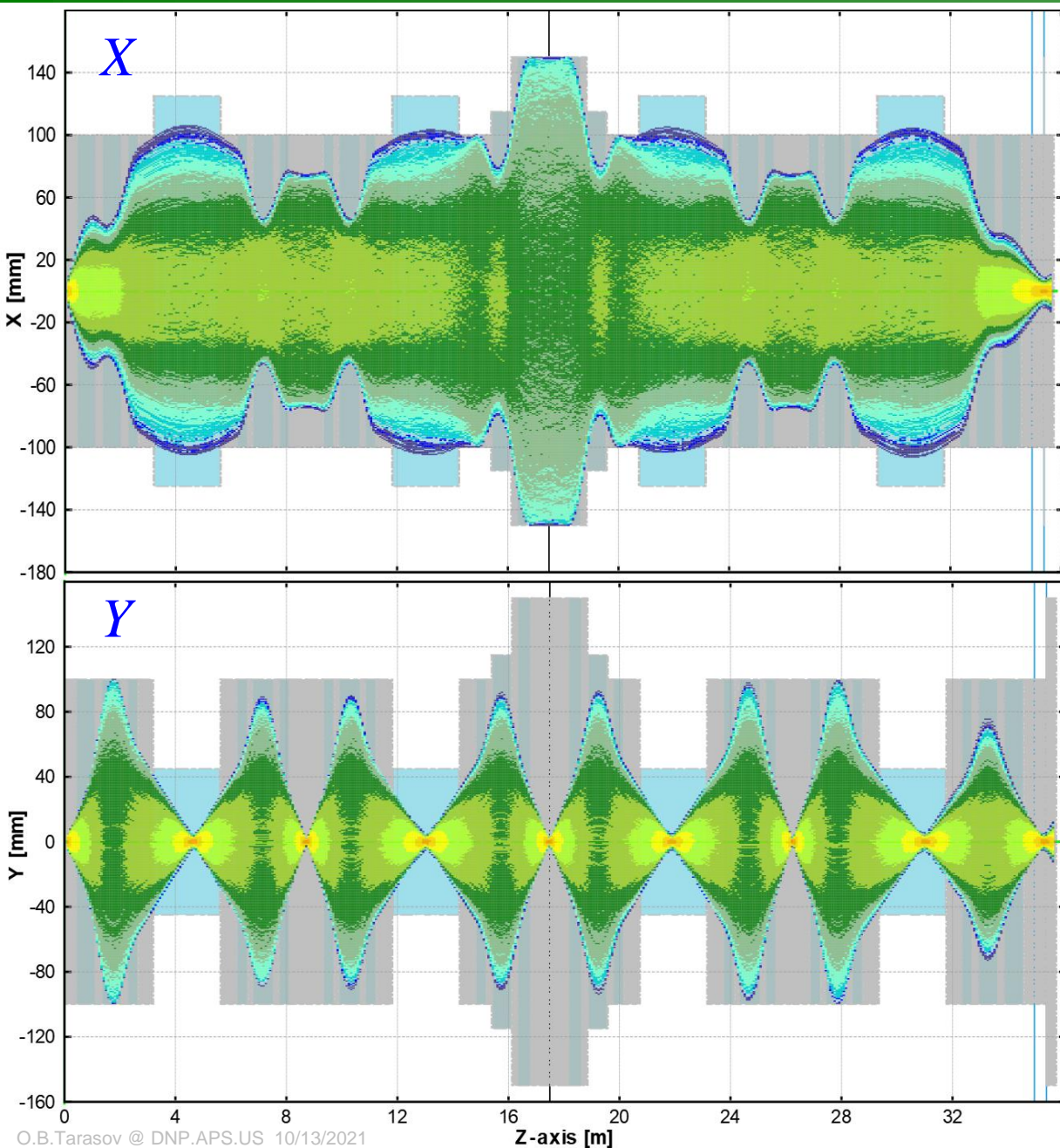
Gate 1

Settings

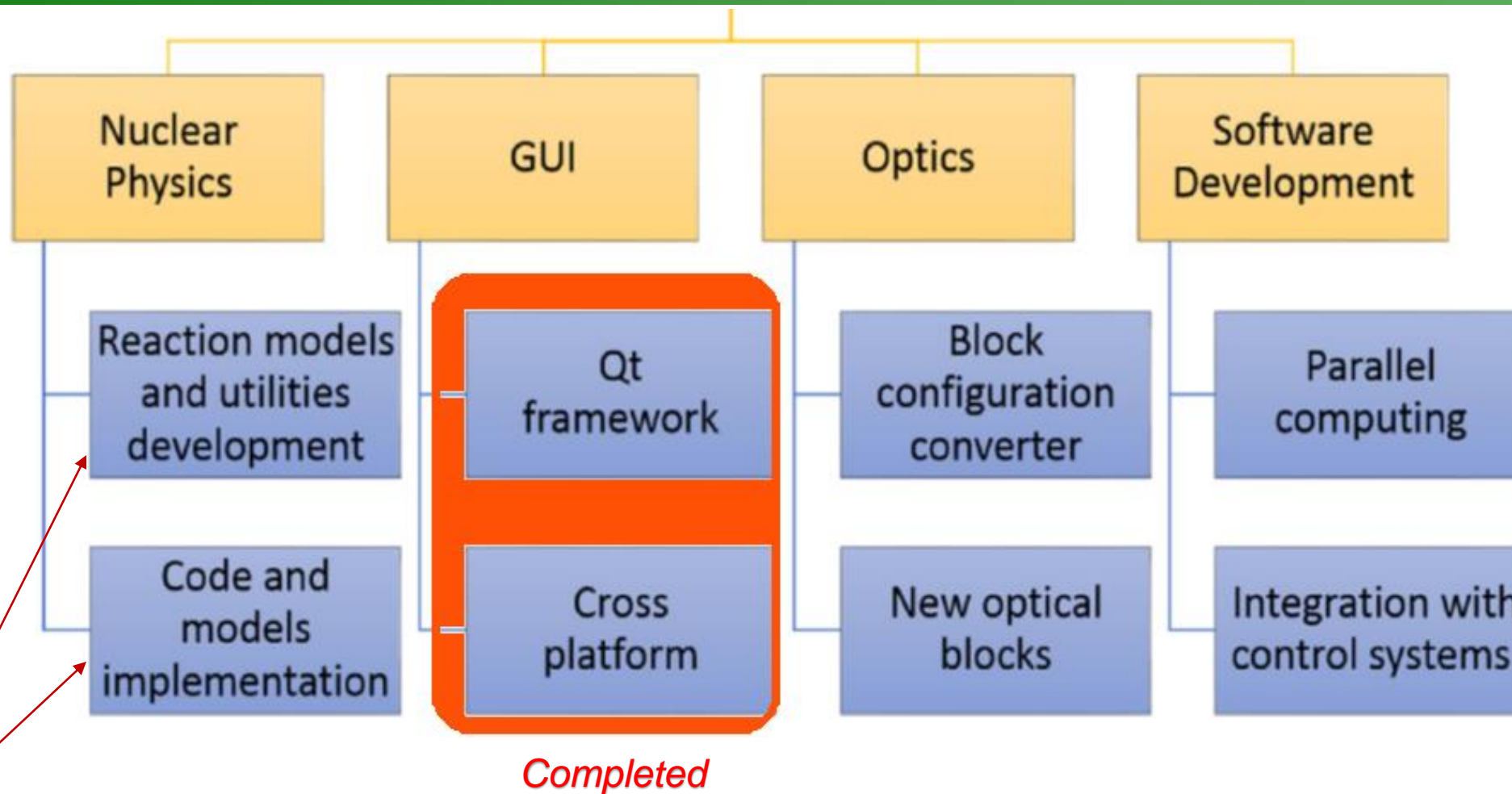
"NOT" [0, 20]

< Angle [mrad] > after Stripper

3-D Monte Carlo Envelope Plots



X⊗Y envelope
A1900



Next Slides

Fig. A schematic diagram of the LISE⁺⁺ development plans.

M.P. Kuchera et al./Nuclear Instruments and Methods in Physics Research B 376 (2016) 168–170

We are very grateful to Dr. Toshiyuki Sumikama (RIKEN) for the fast and quality analysis of bug locations during the porting process

About "ETACHA"

ETACHA

calculating charge state distributions

E.Lamour, P.D.Fainstein, M.Galassi, C.Prigent, C.A.Ramirez, R.D.Rivarola, J.-P.Rozet, M.Trassinelli, and D.Vernhet

PHYSICAL REVIEW A 92, 042703 (2015)

Version 4.4.3
30-SEP-2021

This program has been converted to C++ and ported to MS Windows GUI by O.B.Tarasov (NSCL/MSU) with the framework of the LISE++ program.

This program has been made into a cross-platform application in the Qt framework by K.V. Tarasova

The GUI-version is currently maintained by O.B. Tarasov

ETACHA www.insp.jussieu.fr/ETACHA4-a-code-to-predict-the.html

LISE++ <http://lise.nslc.msu.edu> **LISE++**

ETACHA4 - eUntitled

File Execute Help

Projectile

A	Element	Z	Q
207	Pb	82	64

Energy (MeV/u): Initial 28.9, Final 28.162, Stopping power (MeV/mg/cm²): 75.905, 76.772

Use Energy Loss Calculations

Target

A	Element	Z
12	C	6

Thickness = 2 mg/cm², Density = 2.26 g/cm³

Version

- v.23 Y(1s,2s,2p),Y(3s),Y(3p),Y(3d)
- v.3 + Y(12,3) *fast, for high E*
- v.3.4 + Y(4) *do not use*
- v.4 + Y(123, 4) *default*
- v.4.5 + Y(5) *beta*

IONIZATION model

- CDW-EIS (default)
- PWBA (fast)

EXCITATION model

- Symmetric-Eikonal (default)
- PWBA (fast)

Integration model

- ODE ISBN: 0716704617 (ordinary differential equation solver)
- RKF45 (Runge-Kutta-Fehlberg ODE solver)
- Euler's method

Steps & Numerical uncertainties

Absolute = 1.00e-12, Relative = 1.00e-5, Minimum step = 1 μg/cm², Maximum step = 200 μg/cm²

Corrections for PWBA (parameter "lbin")

- 0: empirical saturation correction (default)
- 1: binding correction included (not recommended)
- 2: no empirical correction and no binding correction

Reaction characteristics

perturbation parameter Kp (n=1) = 0.18, Kp (n=3) = 0.02, projectile velocity Vp = 33.364 au

Finished at 02:00:16, Elapsed time is 00:00:27 (or 27 863 sec)

Final energy : 28.162 (MeV/u)

output data in files:

00 to 09 EE- charge states in C:/Users/taras/Documents/LISEoute/results/e/Untitled_Eta0009.bt

10 to 19 EE- charge states in C:/Users/taras/Documents/LISEoute/results/e/Untitled_Eta1019.bt

20 to 29 EE- charge states in C:/Users/taras/Documents/LISEoute/results/e/Untitled_Eta2029.bt

30 to 39 EE- charge states in C:/Users/taras/Documents/LISEoute/results/e/Untitled_Eta3039.bt

40 to 49 EE- charge states in C:/Users/taras/Documents/LISEoute/results/e/Untitled_Eta4049.bt

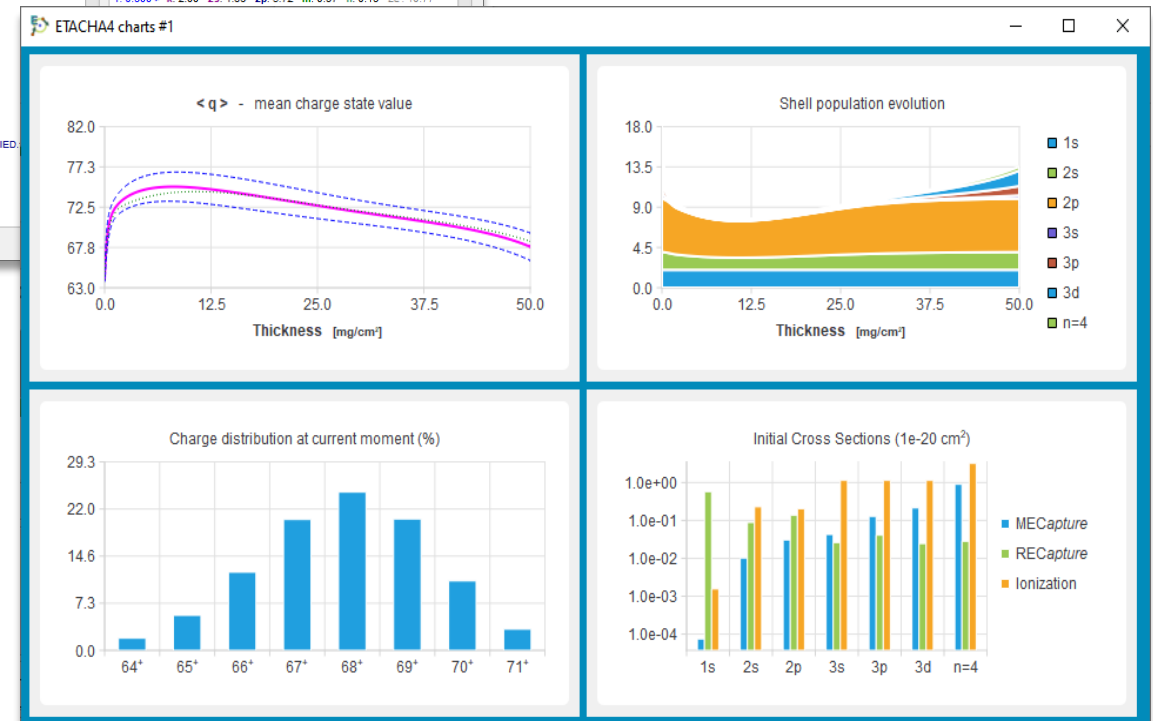
50 to 59 EE- charge states in C:/Users/taras/Documents/LISEoute/results/e/Untitled_Eta5059.bt

60 to 69 EE- charge states in C:/Users/taras/Documents/LISEoute/results/e/Untitled_ETAPIED.bare, 1s,2s,2p,1s2,1s2p,1s2,2s,1s2+2p ions and sum of these in C:/Users/taras/Documents/LISEoute/results/e/Untitled_ETAPIED.mean, 1s,2s,2p,3s,3p and 3d populations in C:/Users/taras/Documents/LISEoute/results/e/Untitled_POPMEAN.bt

WARNING! Next calculation will overwrite these files. Consider saving or renaming these results!

FINAL achieved >> T=2.000 mg/cm² <Q>=73.264 dQ=1.303 E=28.162 dSum=0.000

Ready



ETACHA cross sections

Capture and ionization				Excitation						
(sub) shell	MEC (capture)	REC (capture)	ionization	From / To	2s	2p	3s	3p	3d	n=4
1 1s	7.4753e-5	5.7628e-1	1.5660e-3	1 1s	3.4723e-3	5.9665e-3	5.6845e-4	8.6390e-4	7.3594e-5	5.1577e-4
2 2s	1.0215e-2	8.8511e-2	2.2976e-1	2 2s		6.8601e+0	1.3095e-1	1.2979e-1	4.7504e-1	1.3828e-1
3 2p	3.0644e-2	1.3817e-1	2.0481e-1	3 2p			1.4638e-2	1.5797e-1	5.8280e-1	1.3981e-1
4 3s	4.2868e-2	2.6225e-2	1.1414e+0	4 3s				2.5257e+1		4.4038e+0
5 3p	1.2860e-1	4.0938e-2	1.1414e+0	5 3p					1.1368e+1	4.8968e+0
6 3d	2.1434e-1	2.4563e-2	1.1414e+0	6 3d						6.5730e+0
7 n=4	9.0063e-1	2.8335e-2	3.1926e+0							

Version 4 Ionization: CDW-EIS Excitation: SE

²⁰⁹Pb (28.9MeV/u) + C

Table cells can be edited. All cross sections in 1e-20 cm²

Accept Continue

About GEMINI++

GEMINI++
statistical decay code

R. J. Charity

R.J. Charity, Phys. Rev. C 82 (2010) 014610
D. Mancusi, R. J. Charity, J. Cugnon, Physics Review C 82 (2010) 044610

Version 2.7.3
12-JUL-2021

GEMINI++ has been ported to a GUI application using Qt within the LISE++ framework by M.P. Kuchera, and updated by O.B. Tarasov
The GUI-version is currently maintained by O.B. Tarasov

GEMINI++ <http://lise.nscf.msu.edu/gemini.html>
LISE++ <http://lise.nscf.msu.edu> **LISE++**

Gemini

File About

Execute Open Save About

Compound Nucleus Decay Fusion reaction

Projectile
A = 16 N = 8
Z = 8 ¹⁶O
ME (MeV) = -4.737

Target
A = 12 N = 6
Z = 6 ¹²C
ME (MeV) = 0

Compound
A = 28 N = 14
Z = 14 ²⁸Si
ME (MeV) = -21.4928

Beam Energy
Lab Energy (MeV) 160

Calculation
Q_{CN} = 16.7558
E_{CM} = 68.5714
E_x = 85.3272

Spin
 Input max spin 23
 Max spin from Bass Model

Local settings
Diffuseness of fusion spin distribution (ħ) 2
Number of fusion events 500

Masses
 Traditional Gemini
 AME2016 database

Evaporation mode
 0 = widths (& KE) calculated from Weisskopf, S & L from H.F.
 1 = Hauser-Feshbach formalism (H.F.)
 2 = Switches between options 0 and 1 depending of the ratio of rotational to thermal energy

IMF emission
 use in calculations
 enhanced IMF emission

Gemini

Save Print

Gemini
Statistical Decay Code

Starting Conditions

	Z	N	A	^A EI
Projectile	8	8	16	¹⁶ O
Target	6	6	12	¹² C
Compound nucleus	14	14	28	²⁸ Si

Bombarding energy (MeV) 160.00
Center of Mass energy (MeV) 68.571
Compound nucleus Excitation energy (MeV) 85.33
Q-value of reaction (MeV) 16.756
Compound nucleus recoil energy (MeV) 91.429
Compound nucleus recoil velocity (cm/ns) 2.512e+00
Compound nucleus recoil (β) 8.373e-02
Beam velocity (cm/ns) 4.396e+00
Beam velocity (β) 1.465e-01

diffuseness 2.00 ħ
Fusion cross section 655.27 mb
Bass L 21.02 ħ
L0 20.85 ħ
Bass cross section 675.84 mb
Excitation energy 85.33 MeV
Critical spin 21.0 ħ

Fusion Product Summary

Result	Number
Intermediate Mass Fragments	268
Symmetric Fission	0
Residual Nuclei	232
TOTAL	500

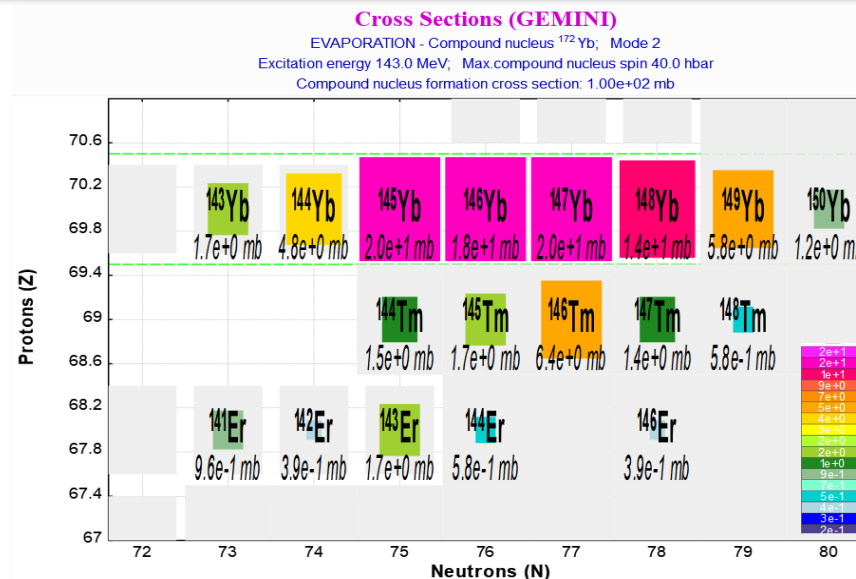
Yields of Residual Nuclei

Z	Name	Events	Percent	x-section (mb)	err(mb)
12	24Mg	11	4.7%	31.07	9.368
12	23Mg	28	12.1%	79.08	14.95
12	22Mg	44	19.0%	124.3	18.74

The Gemini++ code was implemented to the LISE++ package after porting to a GUI application using the Qt graphics framework.

The code was updated to use the AME2016 database and to plot calculation results with the LISE++ code.

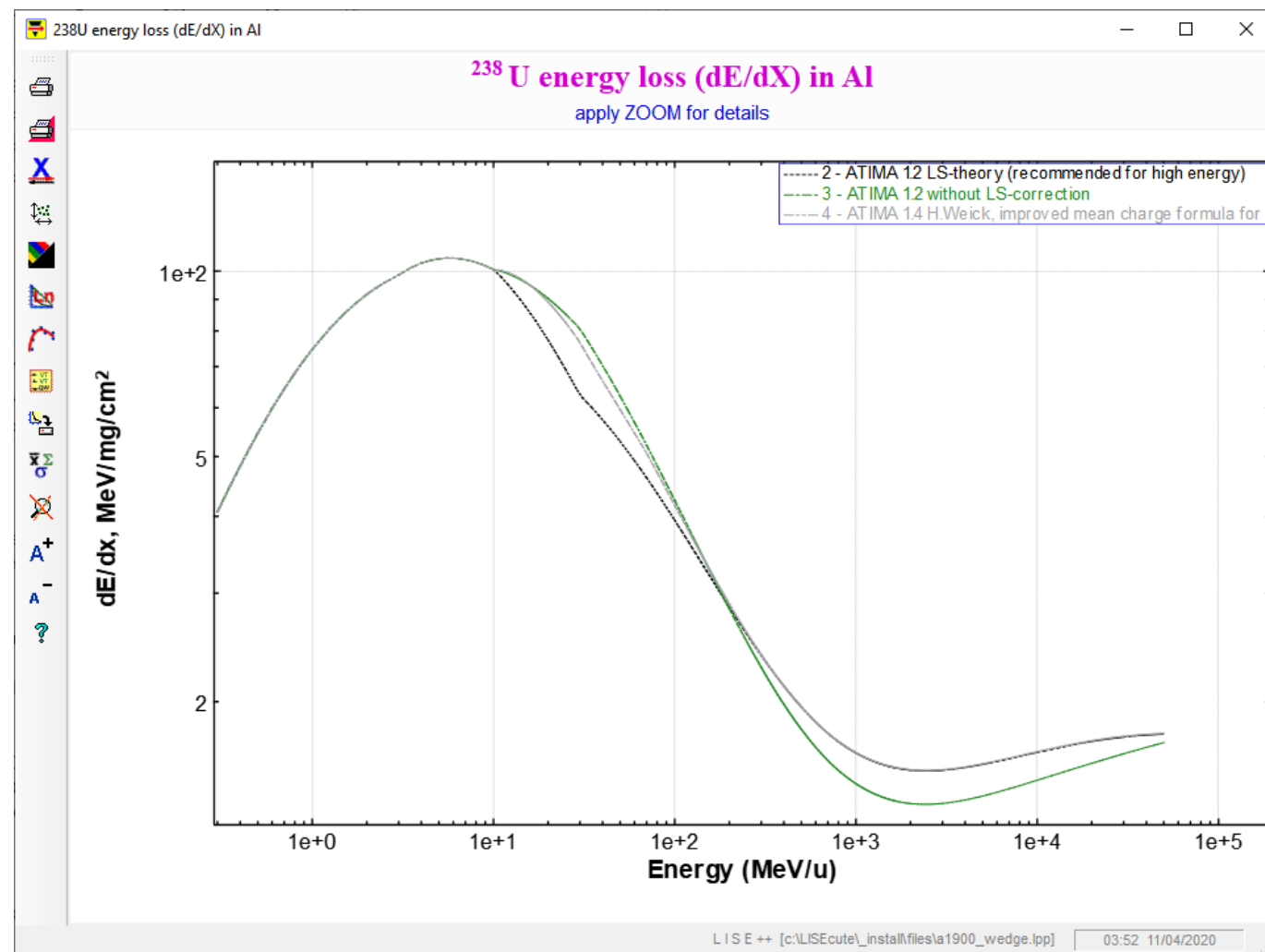
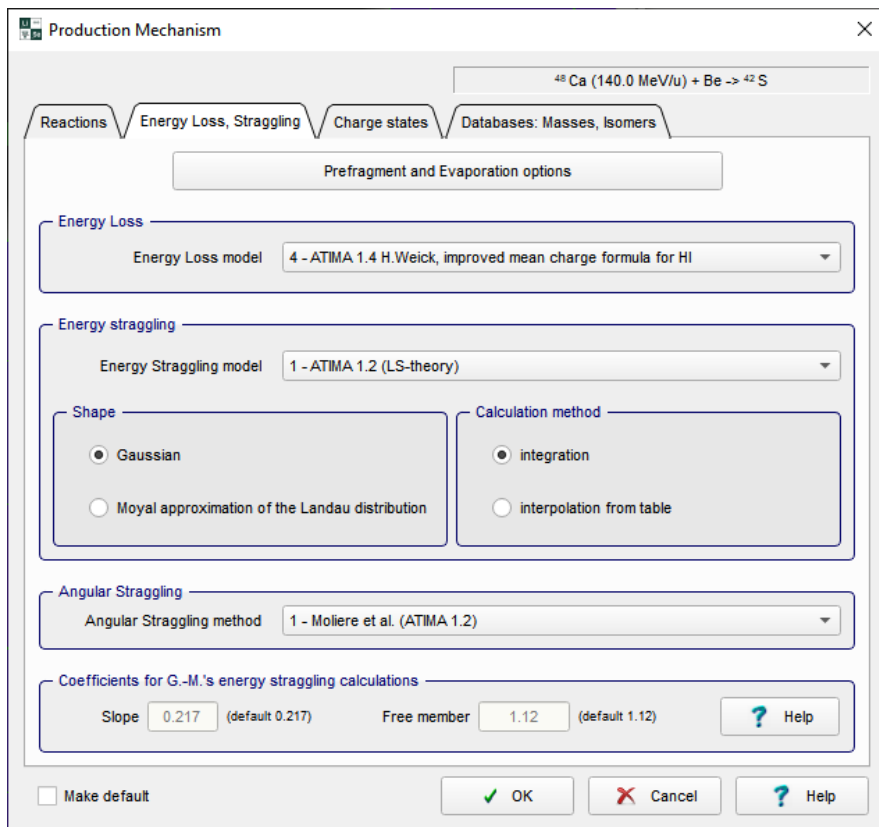
<http://lise.nscf.msu.edu/gemini.html>



Implementation of ATIMA1.4 (catima1.5)

Complete agreement with ATIMA14 site results were obtained

ATIMA 1.4 is set as default Energy loss model in version 15



Acknowledgements to Drs. H.Weick and A.Prochazka

ATIMA website: <http://web-docs.gsi.de/~weick/atima/>

- ❑ The standard LISE 3EER (excitation energy region) model uses only 3 fissile nuclei to calculate fission fragment cross sections. Fast, but there is a large discrepancy for exotic nuclei production, as it is aimed at obtaining the main fission yield.

- ❑ The new utility, Initial Fissile Nuclei (IFN) Analyzer, calculates the contribution from all possible parent fissile nuclei to the final fission fragment, which allows to calculate
 - fission fragment production cross section,
 - more likely fissile nucleus,
 - fragment velocity in CMS,
 - excitation energy of the initial fission fragment,
 - number of nucleons released to reach the final fission fragment.

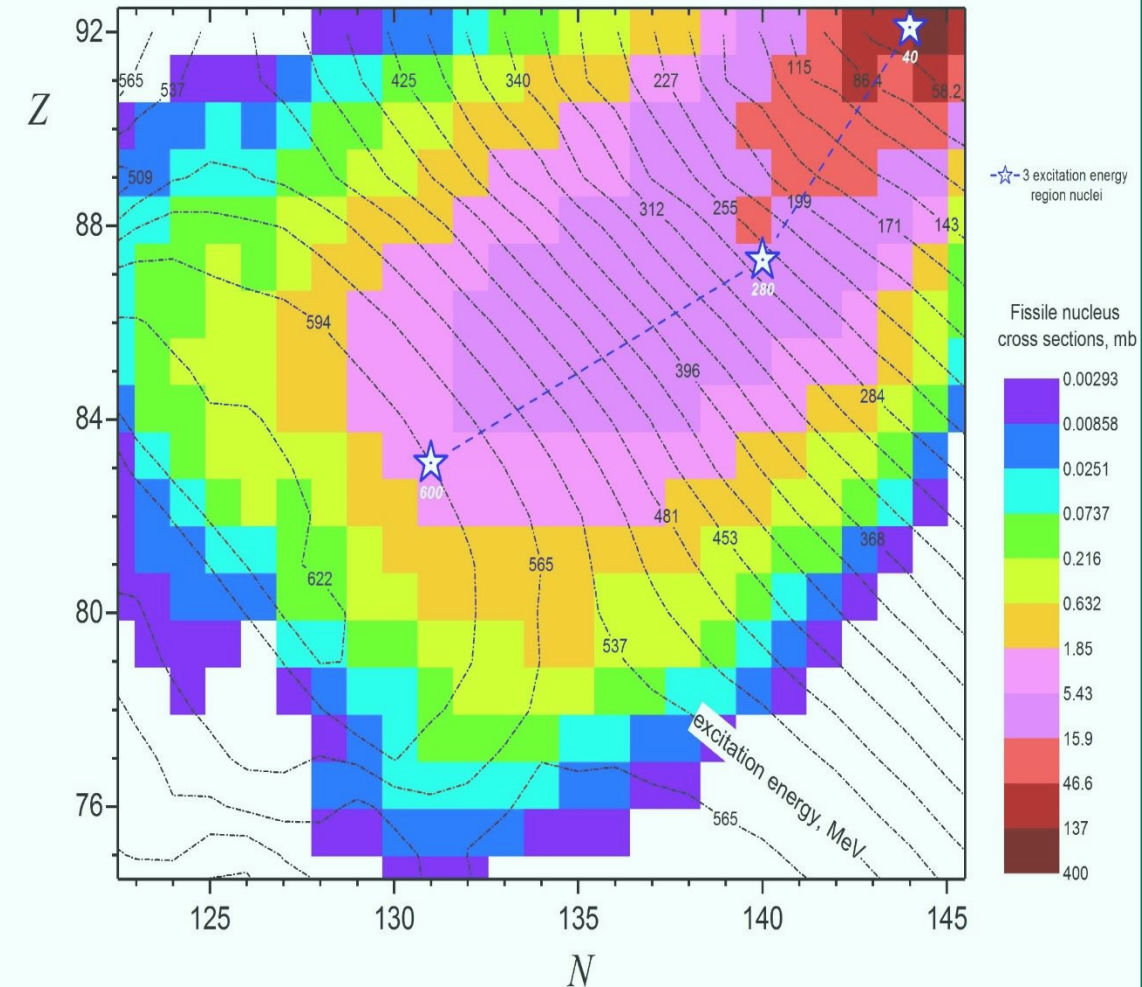
- ❑ Knowledge of the parent fissile nuclei helps to choose a reaction to maximize production of the isotope of interest, transmission factor

http://lise.nsl.msui.edu/10_1/11_0_28_IFN_search.pdf

Abrasion-Fission 3EER model

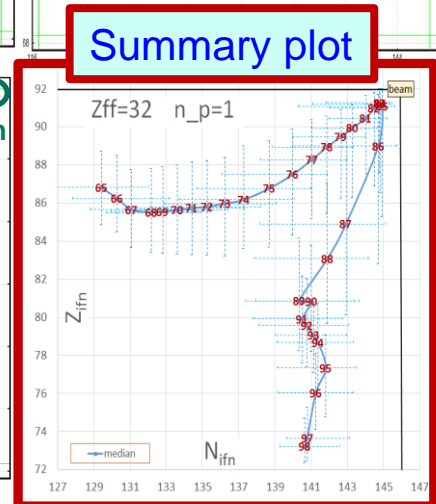
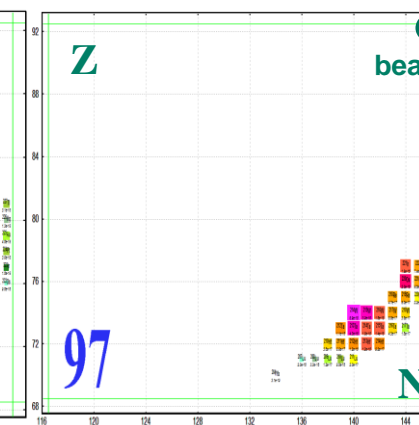
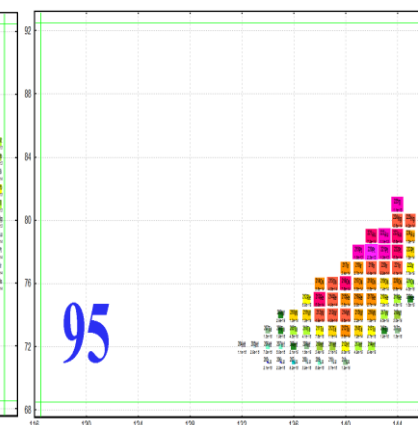
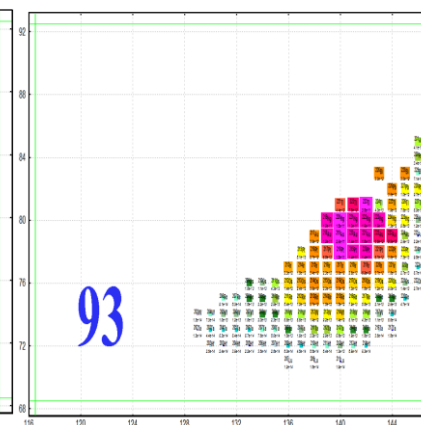
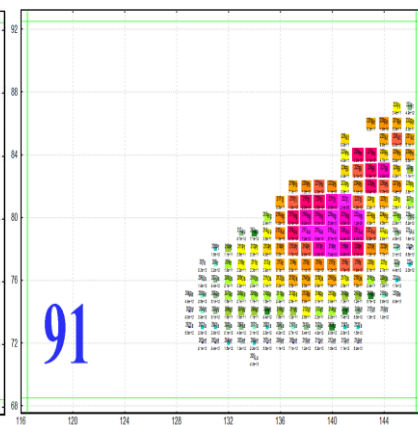
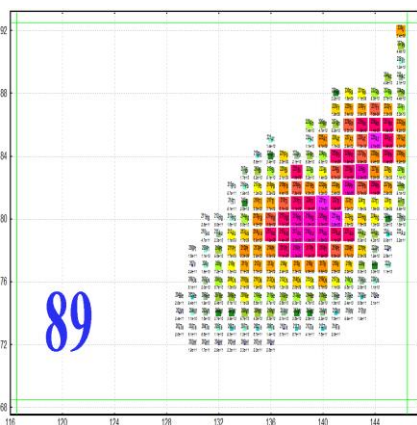
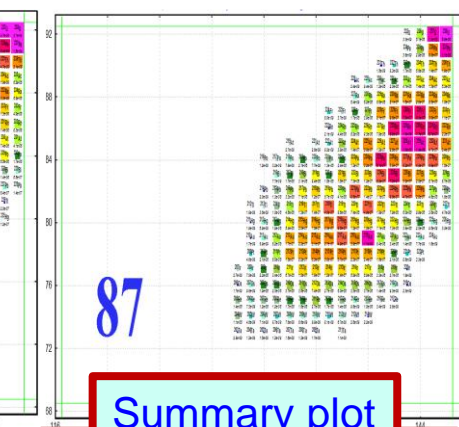
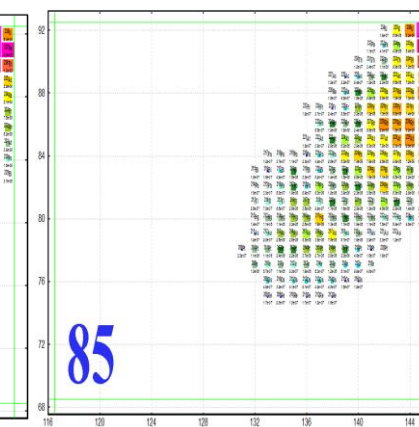
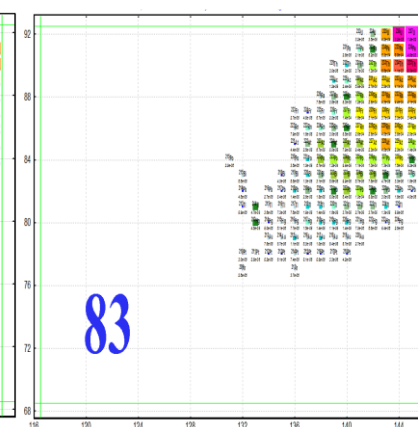
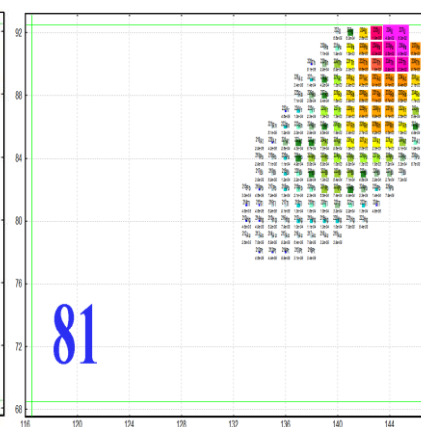
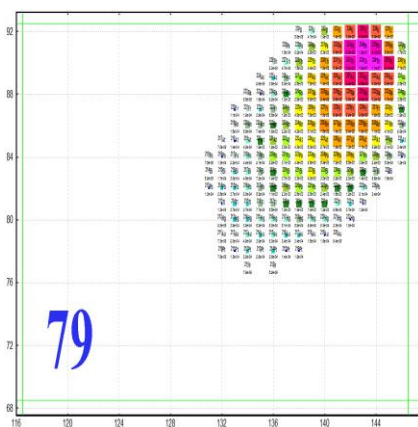
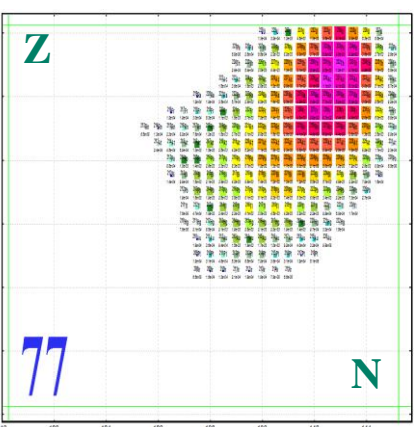
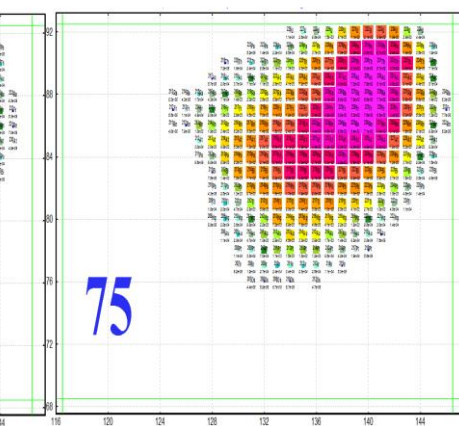
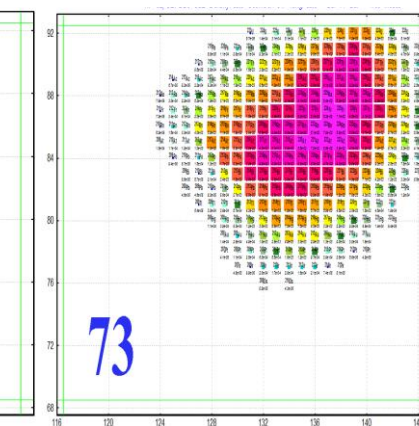
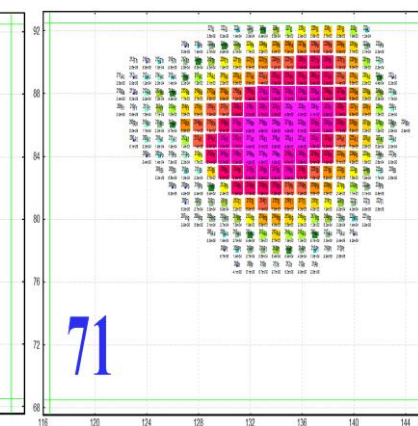
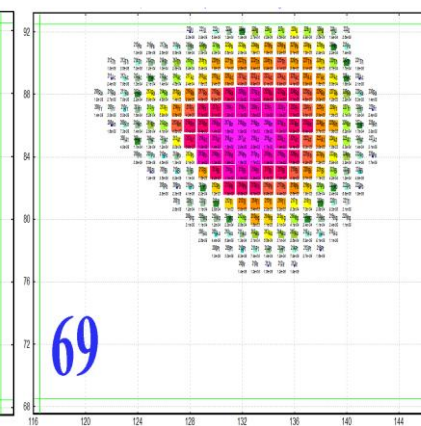
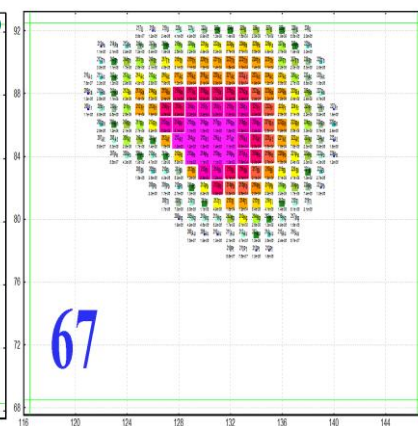
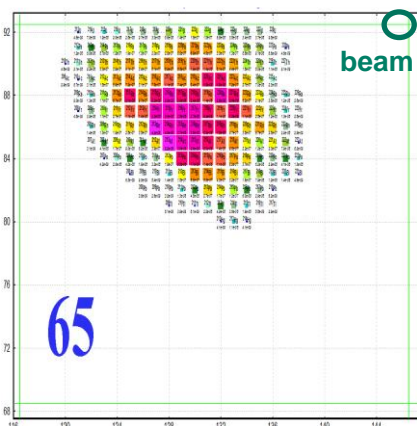
- Fast Analytical model
- Averaging → substitution of more than 1000 fissile nuclei by 3 nucleus

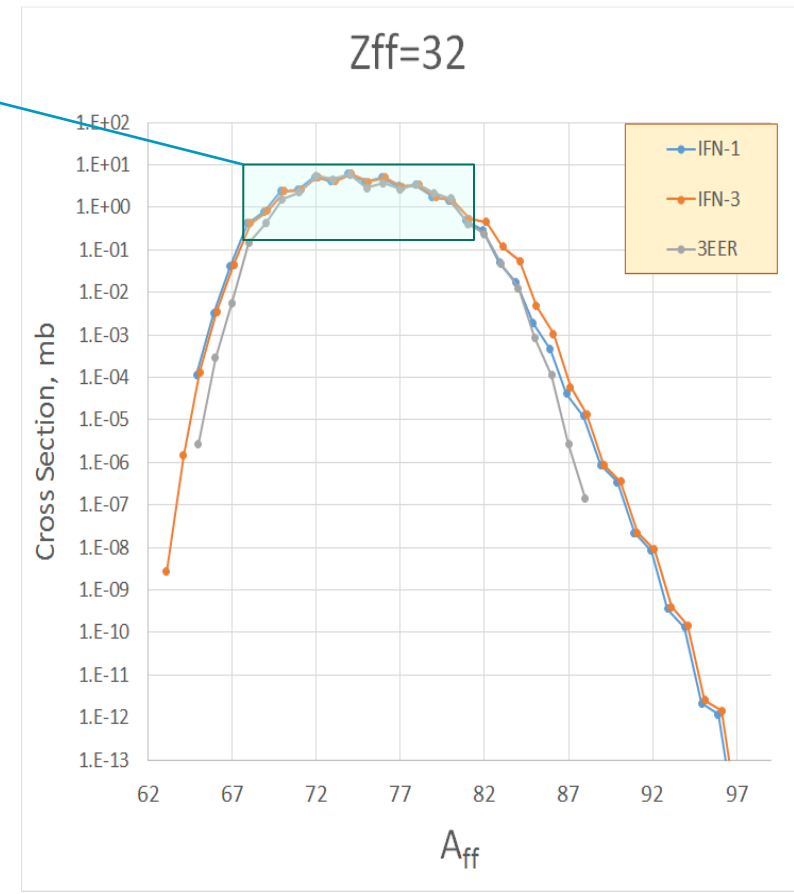
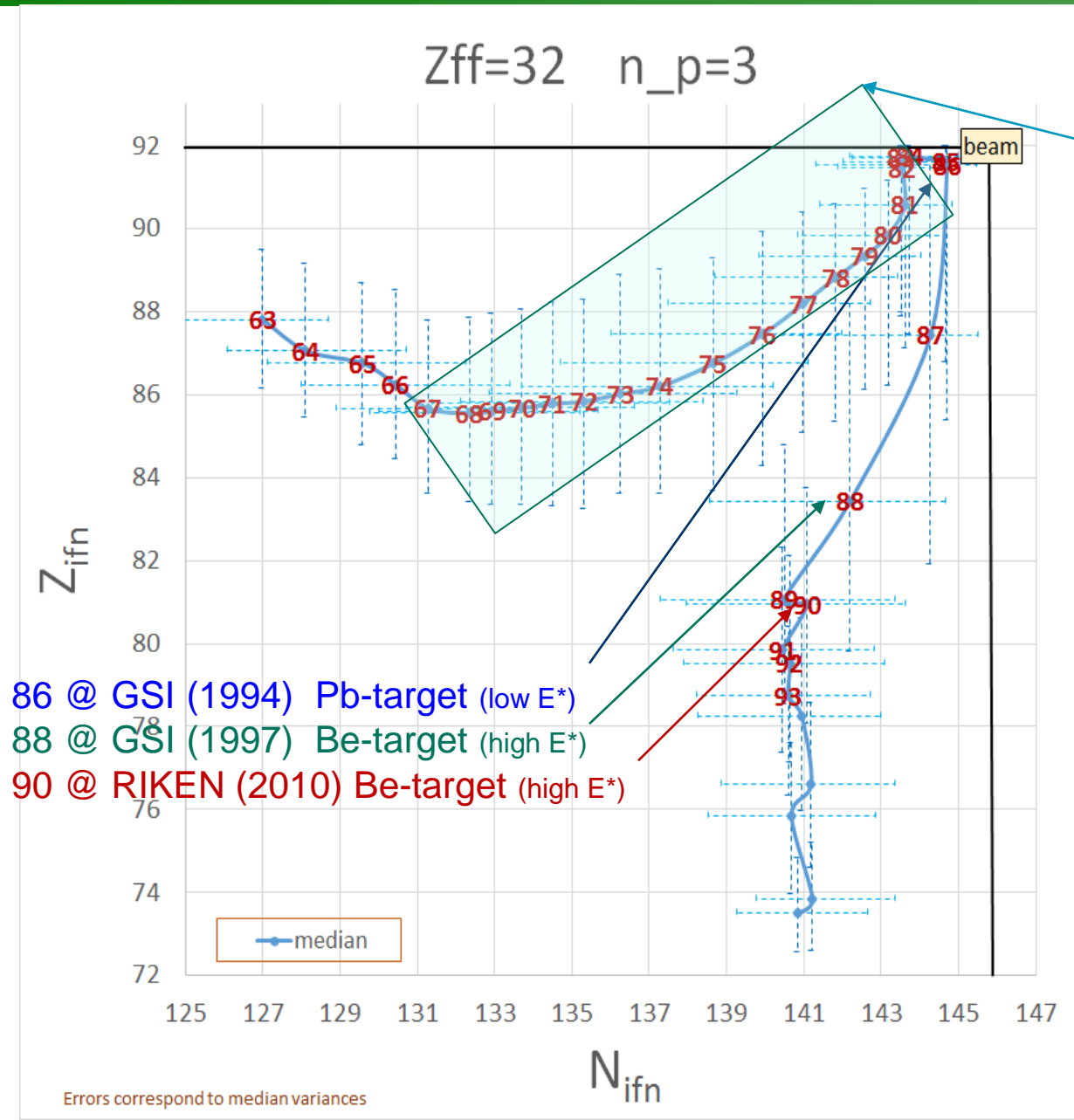
Fissile nuclei map after abrasion of ^{238}U



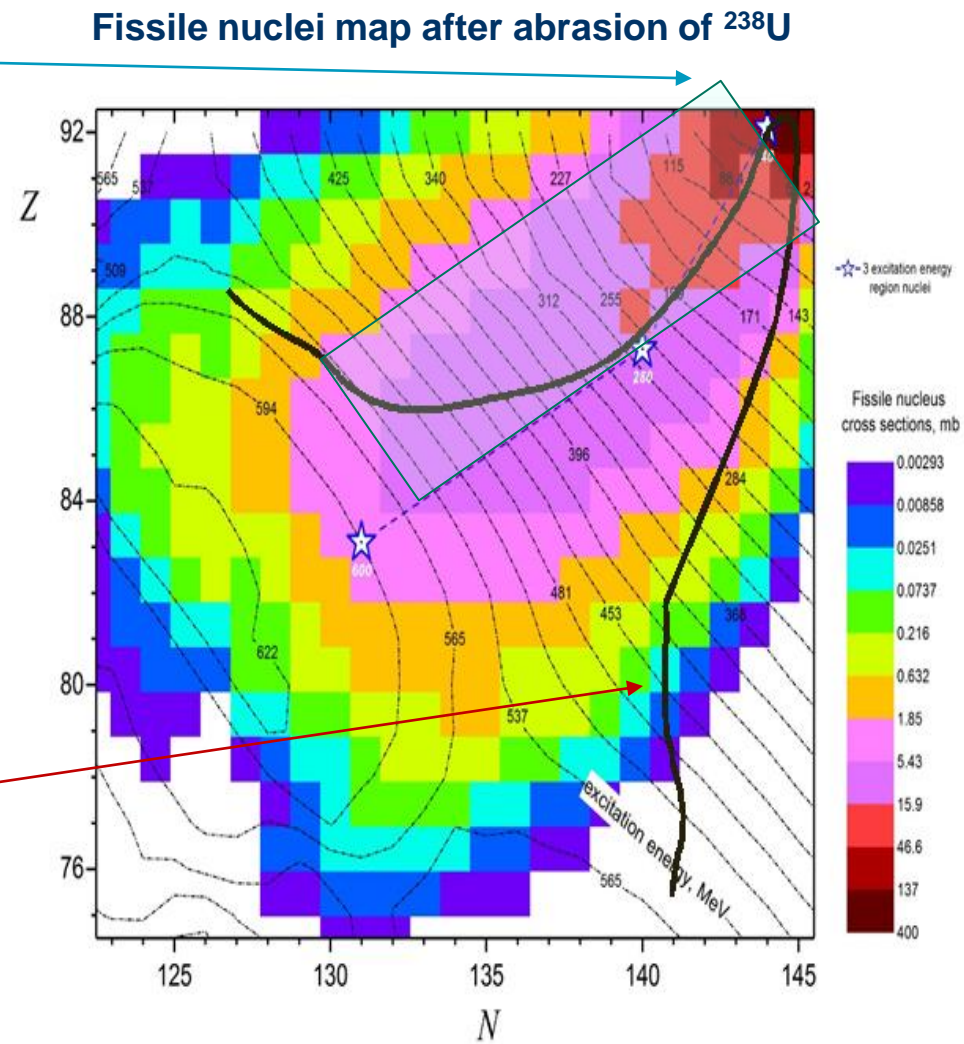
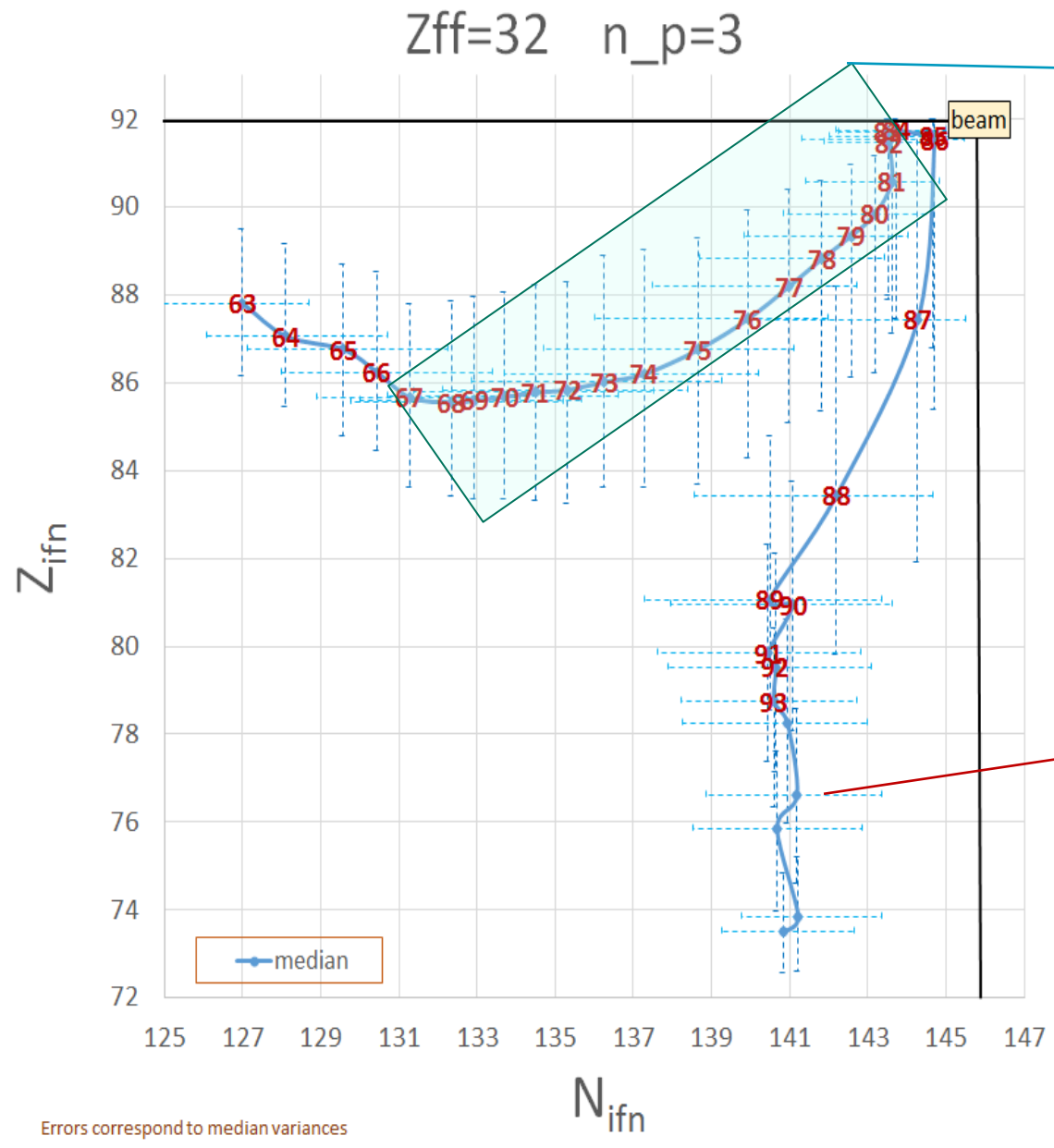


Initial Fissile Nuclei (IFN) for final Ge-isotopes (Z=32)





Very neutron-rich isotopes produced in high excitation fission of nuclei with $Z < 82$. Light Z-target should be used.



The new minimization utility recently developed in the LISE code allows to deduce Abrasion-Ablation model parameters from comparison of AA-calculation results with experimental cross-sections with selection one from 28 mass models distributed with the LISE++ suite. The utility is based on the levmar package using the Levenberg-Marquardt nonlinear least square algorithm.

Abrasion-Ablation: <http://lise.nslc.msu.edu/AA.html>

AA minimizer: http://lise.nslc.msu.edu/10_1/11_0_45_AA_min.pdf

User Cross-Section analysis using the Abrasion-Ablation model: MINIMIZATION ==> 78Kr_2n_ame2016.mfit

This utility can be used if

- "Projectile Fragmentation" reaction mode is selected
- Abrasion-Ablation is the selected cross-section method
- "File" cross section option is set to "on"
- There are more than 2 user cross-sections in memory for this reaction.

Make items 1-3

Local line to analyze: Z=30

Calculate down to Z =

Universal analysis value

Analysis value	Weights	LoD
Local	3	2
Global	0.5	1

Use experimental CS errors in analysis
 Use Reduced chi-square (divide by "n-p")
 if exp. error is absent, then error=coef*CS, where coef is

E* : quadratic polynomial
 <E*> - excitation energy per abraded nucleon (MeV)

0	1	2
0	12.481	0.137
	* d_abr	* d_abr ²

Use in Fitting process
 Use Bounds constraints

Lower bound: 0, 10, -2
 Upper bound: 15, 30, 2

sigma(E*): quadratic polynomial
 Excitation energy std. deviation

0	1	2
0	7.014	0.082
	* d_abr ^(1/2)	* d_abr

Use in Fitting process
 Use Bounds constraints

Lower bound: 0, 4, -2
 Upper bound: 10, 20, 2

AA-X-sections

Amplitude factor	Time Coefficient	Effective Coulomb barrier
0.446	1.65	5.062
<input type="text" value="0.5"/>	<input type="text" value="0.1"/>	<input type="text" value="2"/>
<input type="text" value="1.5"/>	<input type="text" value="10"/>	<input type="text" value="6.5"/>

Thermizn
 dR correction

Press "Escape" to interrupt the analysis.
 "d_abr" is the number of abraded nucleons

mass model: User's ME file [AME2016] + LDM#1

decay channels info: Np=32; Modes=1011 1000 010

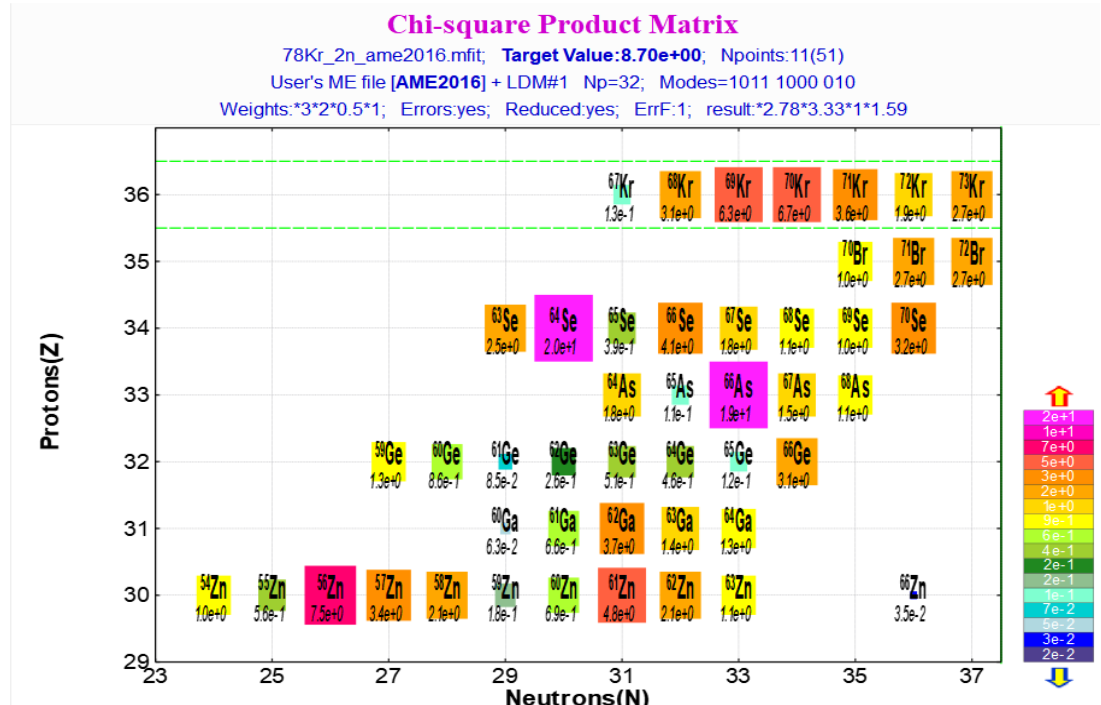
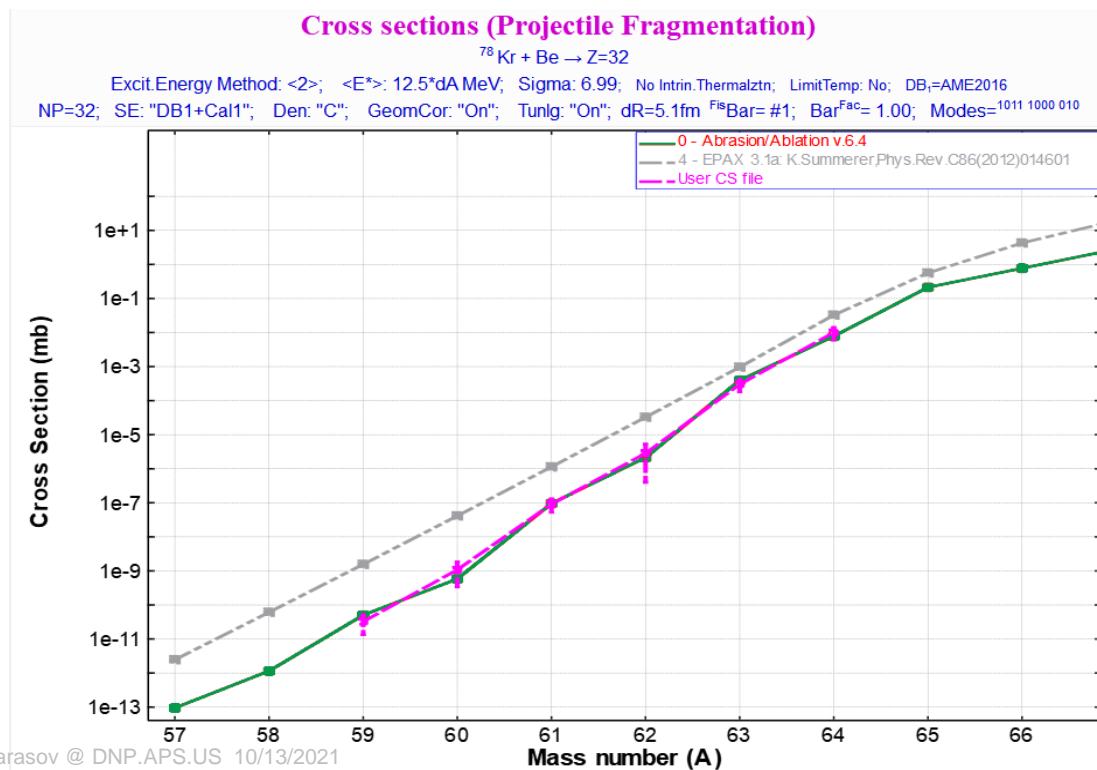
Make default

Fitting: N iterations =

 Plot Product values from the chi2-table
 Target value =
 N CS points =

Operations:

 Analysis Log-file:
 78Kr_2n_ame2016



- Improvement of the fast model for multi-step reactions
- Creation of fast and accurate Abrasion-Fission model based on the Initial Fissile Nuclei Analyzer tables
- Intermediate Dissipation step in the Abrasion-Ablation model
- Implementation in LISE⁺⁺ code for transmission and cross section calculations
 - ETACHA4: Low-energy non-equilibrium charge state evolution
 - PACE4: Projection Angular-momentum coupled evaporation
 - INC: intranuclear cascade model to use at higher energies with light targets
- Theoretical study of prefragment excitation energy
- Systematization of experimental production cross-sections
- Creation of Monte Carlo de-excitation cascade utility to benchmark the analytical LISE⁺⁺ cascade subroutine and to create condition (gating) options
- Investigate charge-exchange and pick-up reactions in RIB production

- The program LISE⁺⁺ is designed to predict the intensity and purity of rare isotope beams (RIB) is widely used at heavy ion collision facilities
- The program is constantly expanding and evolving from the feedback of its users around the world
- Fast and accurate models of rare isotope production mechanism are being developed in the LISE⁺⁺ framework
- The LISE⁺⁺ software suite has been transferred to a new graphics framework, Qt, to use with modern compilers, that provides cross-platform functionality, 64-bit operations
- New code capabilities such as parallel computing, and integration with control systems are planned, so the next step to be undertaken will be the creation of a LISE_{core} library. This library will allow the integration of LISE⁺⁺ with control systems for direct assistance in the tuning of fragment separators. These developments are planned to be tested at FRIB in the near future
- Computational speedup is requested from users at many facilities, and becomes more crucial with the new large-scale nuclear physics facilities under construction, such as FRIB and FAIR, that have keen interest in integrating the LISE⁺⁺ software with their control systems
- **The release of official version 16 is expected in late autumn** (currently v.15 is beta-version)

The LISE⁺⁺ Transportation Team

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

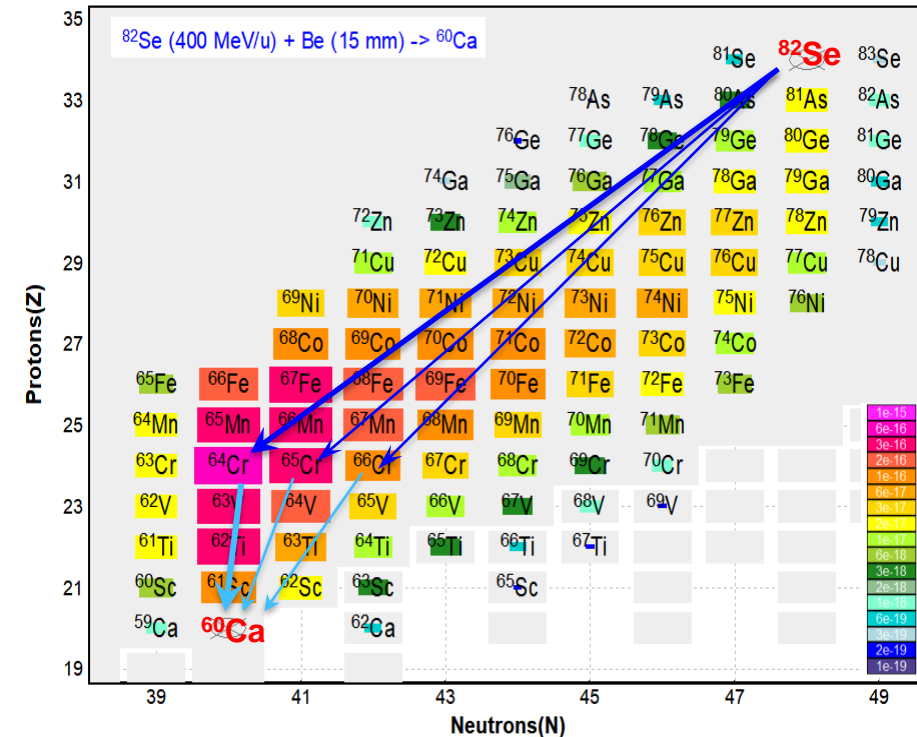
D. Bazin	physics & ion optics consulting, benchmarks, adaptation to macOS
M. Hausmann	physics & ion optics consulting, benchmarks
M. Kuchera	source porting, development of porting process base
P. Ostroumov	supervision, funding acquisition
M. Portillo	physics & ion optics consulting, benchmarks
B. Sherrill	supervision, funding acquisition
O.B. Tarasov	leading porting process worker
K.V. Tarasova	source porting, benchmarks
T. Zhang	process administration, IT consulting, adaptation to Linux

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BACKUP

- Multi-step reactions in thick targets is process then the projectile undergoes a series of successive reactions until the fragment of interest is produced
- For the second and next reactions we assume always a projectile fragmentation mechanism and uses the EPAX parameterization to speed up calculations

Parent nuclei: multistep production probability



LISE++ → ⁶⁴Cr is more probable second-step projectile to produce ⁶⁰Ca with a ⁸²Se beam (400 MeV/u) on Be (15 mm).
 Total Multi-step reaction factor is equal to 10.1

- The study (experimental and theoretical) of the charge-exchange mechanism as a **step for rare isotope production**

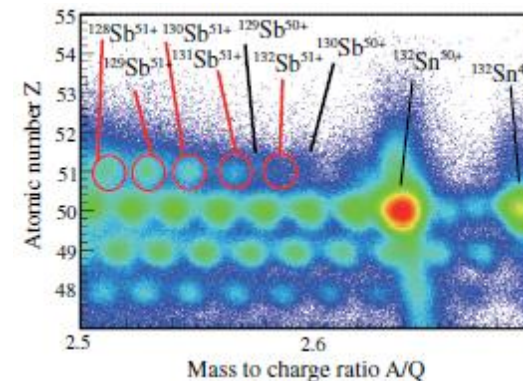
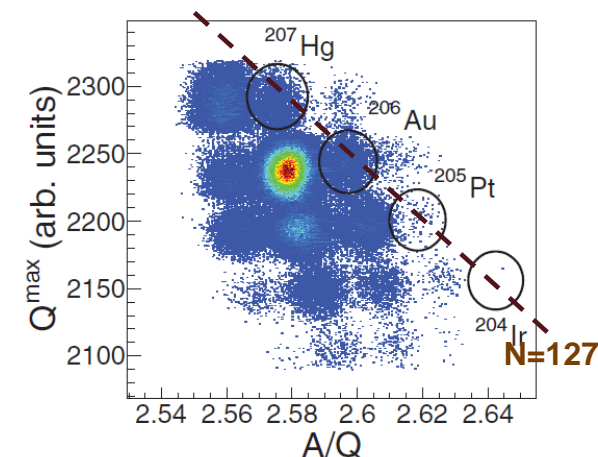
- (p,n)

- A. I. Morales, J. Benlliure et al.,
PRC84, 011601(R) (2011)
 $^{208}\text{Pb}_{126}$ (1 AGeV) + Be

- (n,p)

- J. Yasuda, M. Sasano, et al.,
PRL 121, 132501 (2018)
 ^{132}Sn (200 MeV/u) + H \rightarrow $^{**}\text{Sb}$

- D.Kostyleva, I.Mukha et al.,
PRL 123, 092502 (2019)
 ^{31}Ar (620 MeV/u) + Be \rightarrow ^{31}K

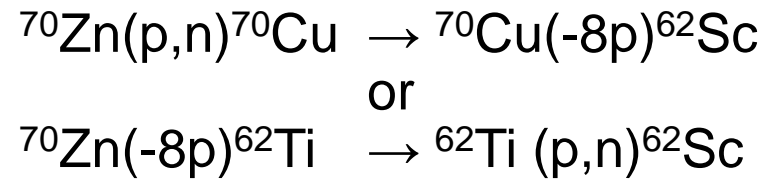


- The study (experimental and theoretical) of the multi-step reactions:
 - the development of a fast model for multistep reactions
 - the measurement of experimental secondary cross sections
- Important to approach the nucleon drip-lines
 - So, more probable path for ^{70}Ca production at FRIB is a three-step process:
 1. Abrasion of ^{238}U to low-excited ^{237}U ($E^* \sim 32$ MeV) with sequential fission to ^{81}Ga ($2e-2$ mb)
 2. First projectile fragmentation step : $^{81}\text{Ga} \rightarrow ^{76}\text{Fe}$ (-5p, $\sim 1e-5$ mb)
 3. Second projectile fragmentation step : $^{76}\text{Fe} \rightarrow ^{70}\text{Ca}$ (-6p, $\sim 1e-6$ mb)
- MSU-RIKEN collaboration recent experiments with multi-step reactions analysis in process:
 - Production of neutron-rich isotopes around ^{60}Ca by projectile fragmentation of a beam of ^{70}Zn at 345 MeV/u (*O.Tarasov et al., PRL 121 (2018) 022501*)
 - Production of very neutron-rich Pd isotopes around $N = 82$ by projectile fragmentation of a RI beam of ^{132}Sn at 280 MeV/u (*H.Suzuki et al.*)

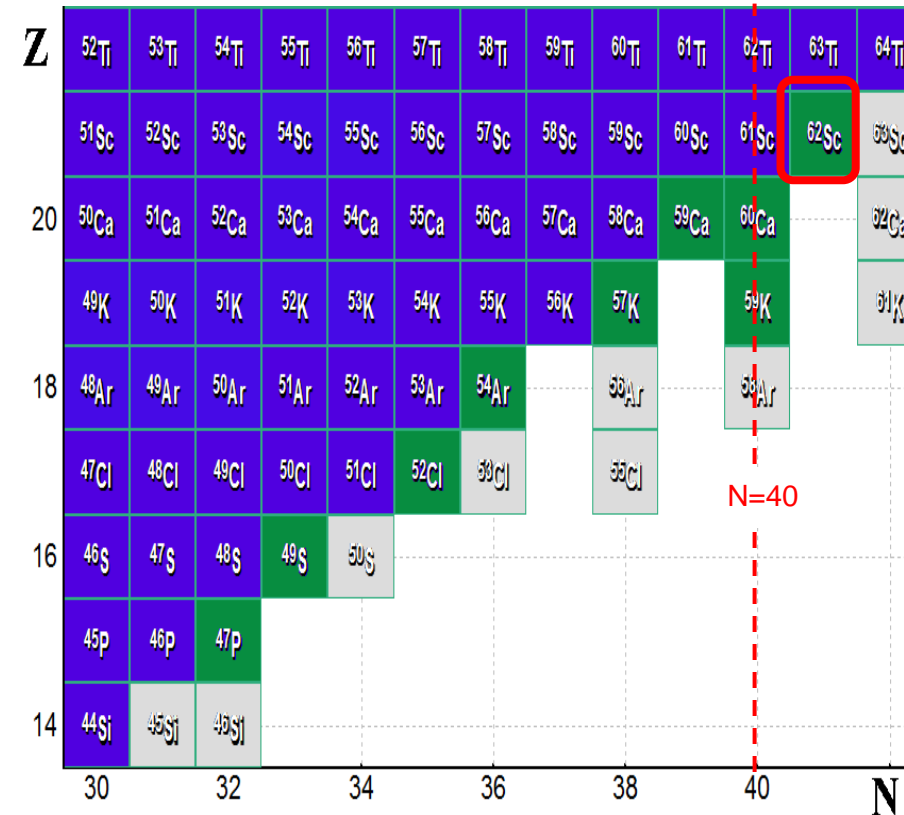
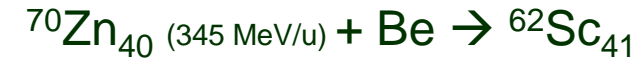
Recent ^{60}Ca experiment at RIKEN

O.Tarasov et al., PRL 121 (2018) 022501

- Production of ^{62}Sc is $-9p,+1n$
- Pickup is suppressed at these energies
- Two-step reactions through a charge-exchange channel?



- Cross sections are under analysis
- Charge-exchange reactions become an important mechanism for the Rare Isotopes production

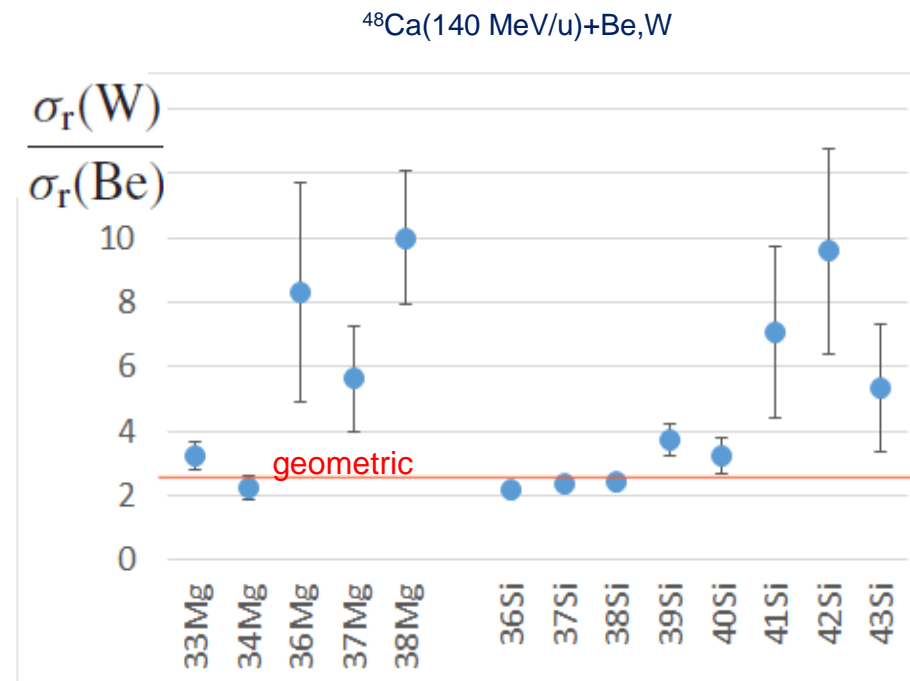


- The study of the target factor in rare isotope yields for energies 50–150 MeV/u

■ $^{48}\text{Ca}(140 \text{ MeV/u}) + \text{Be}, \text{W}$

- ^{40}Mg , $^{42,43}\text{Al}$:
T. Baumann, et al.,
Nature 449 (2007) 1022
- ^{44}Si :
O.B.Tarasov, et al.,
PRC75 (2007) 064613

- $^{198}\text{Pt} (85 \text{ MeV/u}) + \text{Be}, \text{Ni}$
NCSL/MSU, 2019
O.Tarasov et al, under analysis



The cross sections for reaction with the tungsten target are larger than those with beryllium by factors that range from approximately 2.5 at $A = 36$ ($Z=14$) to about 10 at $A = 42$, values that become significantly larger than the ratio of the geo-metric reaction cross sections equal to 2.66

Besides analytical calculation of the transmission and yields of fragments

- Monte Carlo simulation of fragment transmission,
- Monte Carlo simulation of fission fragment kinematics,
- Ion Optics calculation and Optimization ,
- LISE for Excel (MS Windows, Mac OS - download)

LISE++ calculators:

- "Physical Calculator",
- "Relativistic Kinematics Calculator",
- "Evaporation Calculator",
- "Radiation Residue Calculator" (new),
- "Ion Mass calculator" (new),
- "Matrix calculator"
- "Initial Fissile Nuclei analyzer" (new)

Implemented codes:

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

LISE++ Utilities:

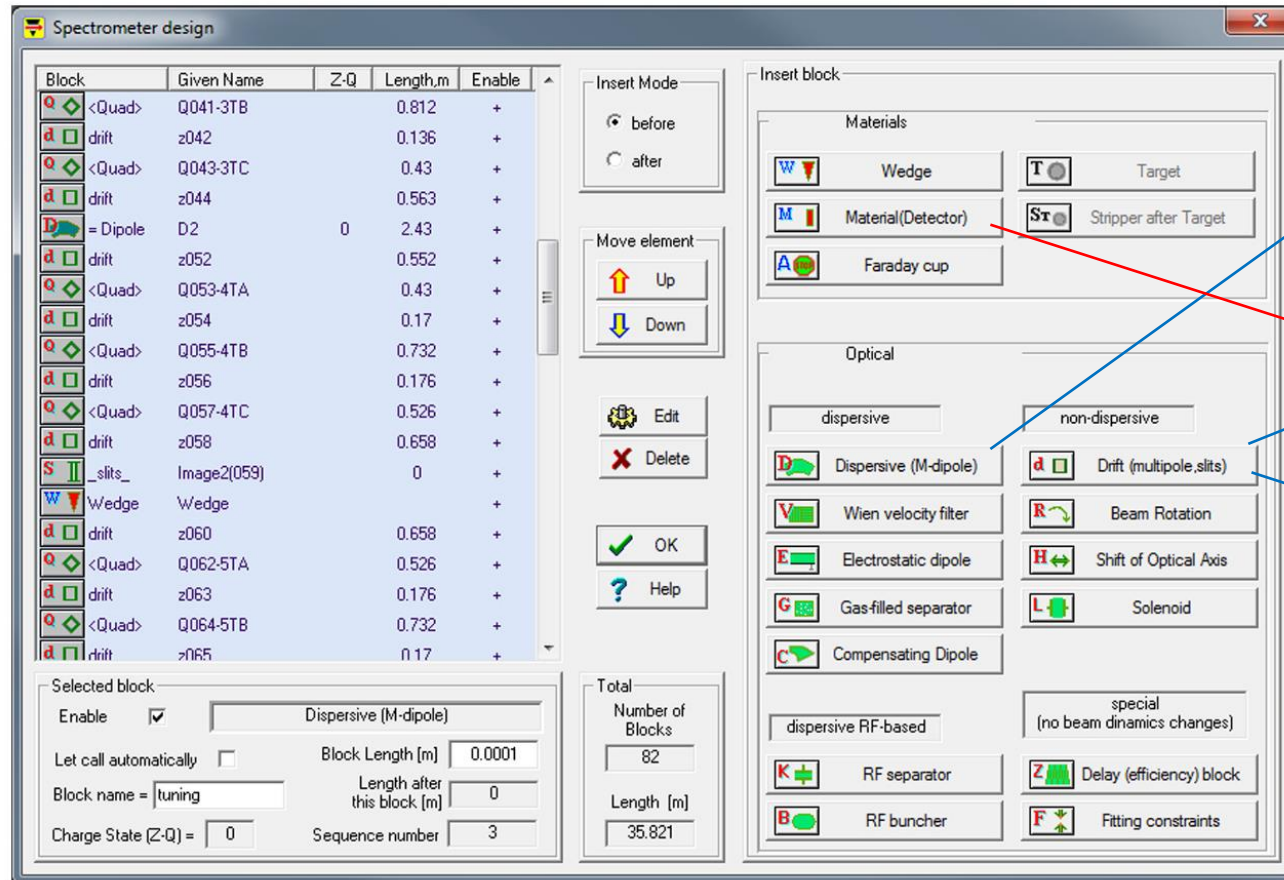
- Stripper Foil Lifetime Utility,
- Brho Analyzer,
- Twinsol (solenoid) utility,
- Units Converter,
- ISOL Catcher,
- Decay Analysis (includes Proton, Alpha, Cluster, Sp.Fission half-lives calculation),
- Reaction Utilities (Characteristics, Converters, Plots),
- «BI»- the automatized search of two-dimensional peaks in spectra

Databases:

- Nuclide and Isomeric State databases with utilities,
- Large Set of Calculated Mass Tables (includes FRIB mass tables),
- Ionization Energy database (used with the Ion Mass calculator),
- Decay Branching Ratio database (used with the Radiation Residue calculator)

Block	Z \ Thickness	MeV/u	MeV	MeV	<Q>
M	Material 2 Si 300 micron	116.39	9072	281.77	27.98
M	Material 3 Si 300 micron	112.69	8784.2	287.86	27.98
M	Material 4 Si 300 micron	108.91	8489.7	294.47	27.97
M	Material 5 Si 300 micron	105.04	8188	301.67	27.97
M	Material 6 Si 300 micron	101.08	7878.6	309.38	27.96
M	Material 7 Si 300 micron	96.996	7560.6	317.99	27.96
M	Material 8 Si 300 micron	92.794	7233.1	327.51	27.95
M	DeltaE Si Si 300 micron	88.439	6893.7	339.43	27.94
M	E Si Si 5000 micron	0	0	6893.7	0.00

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

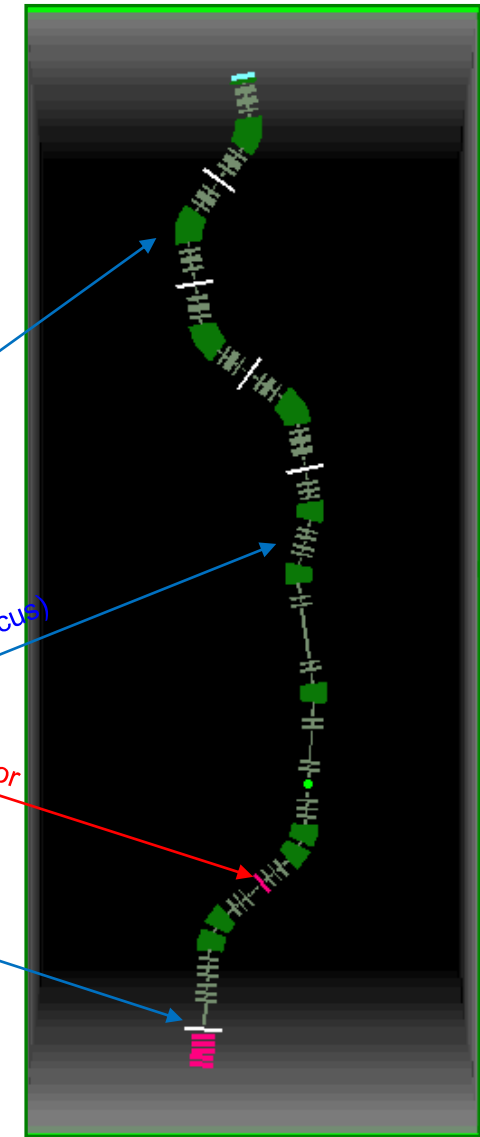


Magnetic dipole (to bend)

Magnetic quadrupole (to focus)

Detector

Slits (to select)



Configuration: A1900_S800BL
(2nd order) 164 blocks

Fig. 1. Updated view of the "Spectrometer Design" dialog window.